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Northeast Region
Inventory & Monitoring Program
Northeast Temperate Network
Woodstock, Vermont

Morristown National Historical Park Amphibian and Reptile Inventory March – September 2000

Technical Report NPS/NER/NRTR—2005/013

ON THE COVER
Northern Green Frog (*Rana clamitans melanota*)
Eastern Red-backed Salamander (*Plethodon cinereus*)
Photographs by: David K. Brotherton

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Technical Report NPS/NER/NRTR—2005/013

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March 2005

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Summary

Under a National Park Service/Wildlife Conservation Society Cooperative Agreement, an inventory of amphibians and reptiles at Morristown National Historical Park in New Jersey was conducted from March through September 2000. Six standardized sampling methods were employed; anuran call counts, egg-mass counts, time-constrained search, coverboards, turtle trapping, and minnow trapping. In addition, animals encountered outside of standardized surveys (temporally or spatially) were recorded as incidental encounters.

The 22 amphibian and reptile species documented represent 68% (21/31) of the species believed to historically have occurred at Morristown National Historical Park. The stinkpot, captured in the Passaic River, was previously undocumented in the park, though it was likely present. Six frog/toad species, seven salamander species, five turtle species, and four snake species were recorded. The northern green frog and American toad, red-backed salamander, eastern box turtle, and eastern gartersnake were the most widely distributed and encountered species in each taxonomic group. The most abundant species in each taxonomic group, based on total numbers of adults encountered were northern green frog, eastern red-backed salamander, eastern box turtle, and eastern gartersnake. The only "listed" species found during the survey was the wood turtle, listed as a *Threatened* species in New Jersey. Two wood turtles were captured and marked in the Passaic River, utilizing both NPS property and the adjacent Scherman-Hoffman sanctuary of the New Jersey Audubon Society. Eastern box turtles, while not officially listed in New Jersey, are a regionally declining species apparently still common at Morristown National Historical Park.

Of the 31 species believed to have occurred historically at Morristown National Historical Park, 21 (68%) were documented in 2000. Of these, 18 appear to be stable in terms of their population trends and the remaining 13 species have declined. Nine of these "declining" species were amphibians not recorded in 2000. Some of this decline is likely due to inherent habitat limitations at Morristown, i.e., it contains few of the pond habitats required to support many of the local amphibian species. Cat Swamp Pond and Cattail Marsh, the two primary pond habitats present at Morristown, have changed, due to the introduction of fish and plant succession, respectively, to the detriment of their value as amphibian habitat. Also, much of the decline seems to involve species that, due to limitations of habitat, were probably never very common to begin with. Their apparent disappearance from Morristown is likely part of a larger, regional decline, in concert with the increasing isolation of Morristown.

Each survey method was useful in sampling different habitats and specific species, and it is recommended that any future inventories targeting the entire herpetofauna include each method, and sample both upland and wetland habitats. Conversely, an inventory targeted at a particular species will need to sample specific habitats using only one or two methods. The method that documented the most species was incidental encounters, which recorded 18 of 22 species found during this inventory. Ten species each were recorded during stream, woodland, and wetland time-constrained surveys, eight with minnow trapping, five with coverboards, two with turtle trapping, and one each with amphibian call counts and egg mass counts. Sixteen species were documented in upland habitats, followed by 15 in streams, and 14 in wetlands. Of the 45 localities (25 standardized sampling sites plus 20 incidental encounter locations) at which amphibians and reptiles were recorded, 64% (29) were uplands, 18% (8) were streams and 18%,

(8) were wetlands. While a detailed plan for monitoring is beyond the scope of this inventory, the results suggest that, in terms of both feasibility and priority, a monitoring program based on time or spatially constrained surveys, coverboards, and aquatic minnow trapping would be the most useful methods for generating quantitative data useful for trends analysis.

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Introduction

Morristown National Historical Park (MORR) is a park rich in history extending back to the Revolutionary War era. The natural areas served as winter encampment sites for General George Washington's American Continental Army between 1779-1780. The Washington Association became the principal caretakers of the property in the 1800's, preserving much of the heritage and accumulating numerous historical artifacts. On March 2, 1933, Morristown became the third historic park added to the National Park Service, the first titled a National Historical Park, incorporating Ford's Mansion, Jockey Hollow and the site of Fort Nonsense. The park is located in Somerset and Morris Counties, in the Highlands section of New Jersey (40^{o} 46' N, 74^{o} 31' W), approximately 366 m (1,200') above sea level. The forests of Morris County are comprised primarily of mixed oak, sugar maple-hardwood, hemlock-hardwood, and chestnut oak forests (Natural History Information Service 1975). These forested areas are underlain by Precambrian gneiss and granite rock and Mesozoic siltstone, shale and sandstone sedimentary rock below the extension of late Wisconsinan glaciation, the last glaciation to affect New Jersey. These rock foundations are among the oldest in New Jersey, formed between 1.3 billion and 750 million years ago, and collectively create valleys flanked with high ridges and an erosion resistant environment resulting from the Precambrian rocks (Division of Science and Research 1996). Morristown National Historical Park's total of 682 ha (1,685 ac) are predominantly deciduous forest, but also includes open fields, and a mixture of wetlands including one permanent pond, numerous seeps, small streams, and a half-mile section of the Passaic River.

In 1998, a Cooperative Agreement between the National Park Service and the Wildlife Conservation Society was formed to assess amphibian and reptile assemblages within the parks of the "New England Cluster" of the National Park Service. As part of this inventory project, Morristown National Historical Park was surveyed from March through September 2000. While the goals of the project vary between parks, they generally are as follows:

- Inventory and record at least 90% of the species currently estimated to occur in the park.
- Determine the occurrence and status of species of management concern (e.g., state and federal *Threatened*, *Endangered*, and *Special Concern Species*, and other declining species).
- Determine abundance categories, distribution, and habitat use of documented species.
- Identify critical habitats of *Threatened*, *Endangered*, and *Special Concern* species.
- Provide basis for future development of a long term monitoring program.
- Analyze species occurrence against historical occurrence and evaluate the state of the park's herpetofauna, on a site and regional scale.

An "estimate" of species historically present at MORR was generated using National Park Service species lists, park files, NPS sponsored reports, and discussion with park staff and others familiar with local herpetofauna. There are no accounts of the herpetofauna of MORR prior to 1980. Existing information was recorded during water quality research projects, as natural history observations by park staff, or as incidental observations by naturalists visiting the park (Kent 1980; Mele 1981; Mele and Mele 1983; Morristown NPFauna 1993; NPS Natural History Observations 1983-1999; Rosato 1998). Due to the paucity of information, we also included observations from the adjacent Scherman-Hoffman Sanctuary (N.J. Audubon Society 2003),

which has habitats similar to MORR. Collectively, these sources report 34 species, including northern black racer (*Coluber c. constrictor*) and northern brownsnake (*Storeria d. dekayi*), which were only recorded on the adjacent N.J. Audubon property. Questionable records of northern copperhead in MORR report this species on 5 June 1988 on Route 24 near Delbarton School, and on 18 May 1999 on a wooden bridge along the Grand Loop Trail (NPS Natural History Observation 1988, 1999). Given the questionable nature of these reports and the lack of data to substantiate the presence of this species, either historically or currently at MORR, we did not consider this species to be a member of the herpetofaunal assemblage at MORR. A timber rattlesnake (*Crotalus horridus*) was reported on 14 June 1989 at Flat Rock (NPS Natural History Observation 1989). Listed as *Threatened* by the New Jersey Department of Environmental Protection, this once widespread and regionally common species has declined in the state due to habitat loss, illegal collecting, roadside mortality, and unjustified killing (Schwartz and Golden 2002). Because of behavioral, temporal, habitat, or any other supportive anecdotal information from local naturalists, we believe this observation to be a mistaken identity and we did not consider this species to occur now or in the recent past at MORR. A single unverified report of an eastern ribbonsnake (*Thamnophis sauritis*) (NPS Natural History Observation 1983) is questionable. Given this was the only report of this species in the park over the past 20 years and that it could easily be confused with the eastern gartersnake (*Thamnophis s. sirtalis*), we did not consider this species to have been historically present. Thus, of the 34 species reported, based on the strength of the records, i.e., their source and numbers, 31 were considered as likely to have occurred historically at MORR (Appendix 1).

A combination of six standardized survey methods were used in the inventory. In addition, incidental encounters were recorded to provide additional information on species presence and distribution in the park. The habitat type of all sites where amphibians and reptiles were found was described, and the species and the habitat types they occupied were analyzed.

Study Area

MORR is located in western Morris County and Somerset County, north-central New Jersey, approximately 48 km (30 miles) west of New York City. The park includes four separate units totaling 682 ha (1,685 ac) of land, most of which is located outside city boundaries in residential areas. Only two of these units, Jockey Hollow and the New Jersey Brigade (Figure 1), can be regarded as "natural areas" and were included in this herpetological inventory. The Jockey Hollow Unit is the largest area (534 ha/1,320 ac) and lies approximately 8 km (5 miles) southwest of Morristown. It is 53% mature forest (269 ha/664 ac), 38% successional forest (180 ha/444 ac), and 9% field/open habitats (49 ha/122 ac)(Ehrenfeld 1977). The New Jersey Brigade Unit (130 ha/312 ac) is adjacent to Jockey Hollow, and is a mixture of forest types dominated by tulip tree (*Liriodendron tulipifera*), black birch (*Betula lenta*), and chestnut oak (*Quercus prinus*) (NPS 1998). A single footpath, the Patriots Path Trail, connects the Jockey Hollow Unit to the New Jersey Brigade Unit. MORR is bordered by Morris Area Girl Scouts of America Council land to the west, Lewis Morris County Park to the north, and the 107 ha (265 ac) Scherman-Hoffman Sanctuary of the New Jersey Audubon Society to the south. Old Jockey Hollow Road creates the western boundary for the New Jersey Brigade unit of the park, while U.S. Route 202 lies adjacent to the southeastern segments and Tempe Wick Road intersects the southern portion of the Jockey Hollow Unit. Western Avenue enters the park from the north and becomes part of the tour loop road in the park.

Aquatic habitats in the park include several streams and tributaries arising from springs, the Passaic River, one permanent and a couple of temporary ponds and marshes (NPS 1993). As part of the Great Swamp Watershed (a subunit of the Passaic River Watershed), the headwaters of wetlands within the park originate both within and beyond park boundaries.

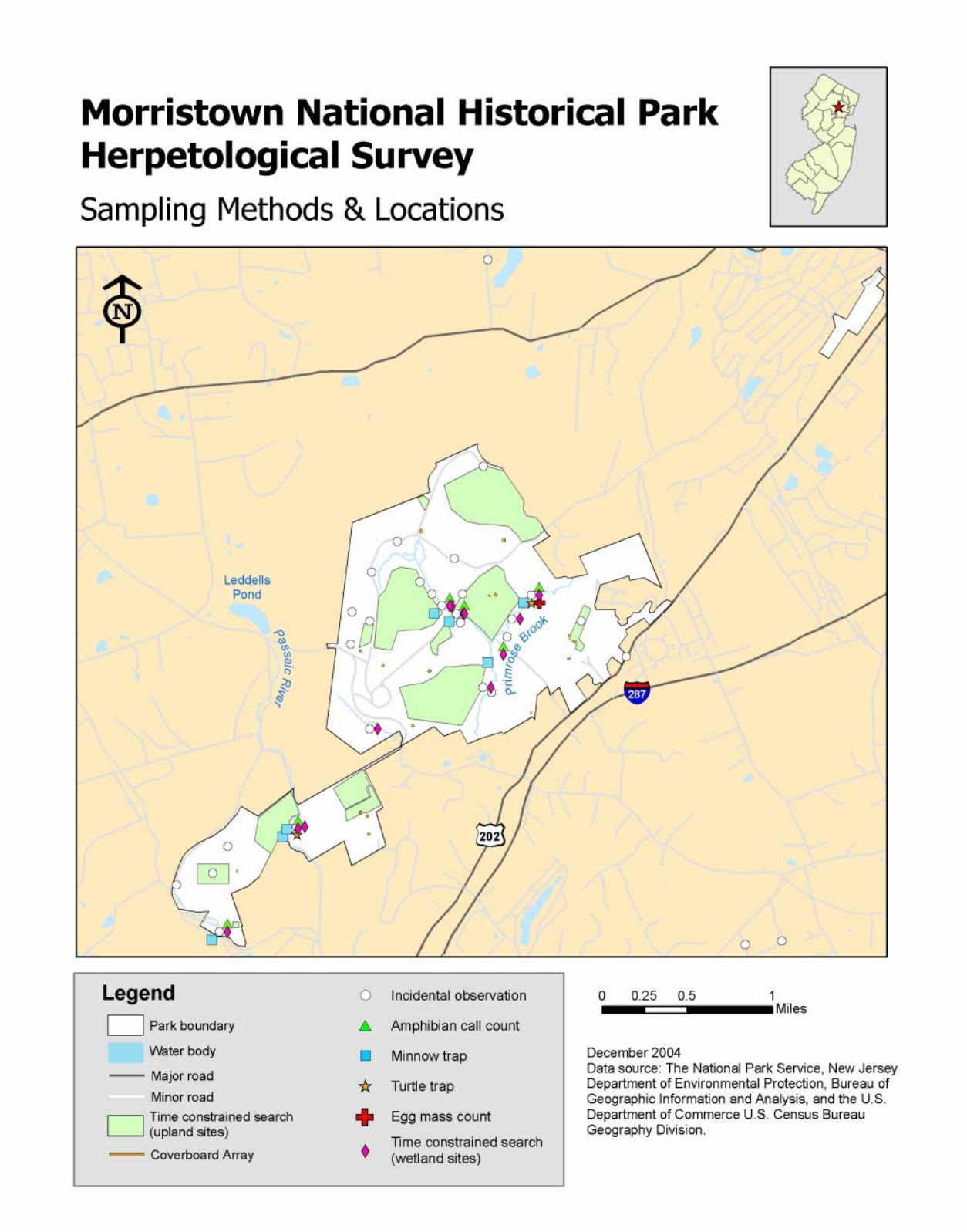

Figure 1. Location of standardized sampling sites and time-constrained search areas used in herpetofaunal inventory in Morristown National Historical Park 2000.

Land Use History

Historically, the land at MORR was farmed as croplands, maintained as pastures for grazing livestock, and woodlands for harvesting wood and supporting soldiers during General Washington's encampment in 1779-1780 (Ehrenfeld 1982). Forested areas were cleared as early as 1740, with the settlement of the first New Jersey residents, and again on a larger scale by General Washington, marking the first major disturbance to the land. Between Washington's encampment and the 1933 establishment of the land as a national historical park, there was no extensive forest clear-cutting (Ehrenfeld 1977). The initial succession of the cleared lands back to forested lands is seen by the increase of boundary trees and tree species within Morris County. Between 1750-1800 there were six species represented in 16 total trees, as compared to 11 species among the 34 total boundary trees in 1982. By comparing early land deeds with those from subsequent years, a change in species composition and forest succession is apparent within the Jockey Hollow Unit. Deeds acquired before 1800 had approximately 75% xeric oaks (black and white oak) and hickory and only 12% of mesic and chestnut trees. Conversely, land described in subsequent deeds were only 25% xeric oaks, but were 38% mesic red oaks and chestnut trees. Overall, the more recent documents indicate greater species diversity than the earliest deeds (Ehrenfeld 1982).

Just prior to becoming a national historical park, the majority of the forested land in MORR was older than 60 years, with a smaller allotment maintained as non-forested grasslands, pastures, crop fields, or orchards. Active farming of the agricultural land in the park ended with the 1933 declaration of the land as a national historical park. However, some areas were preserved as open lands and maintained for historical purposes and appearances. Between 1968–1970 defoliation by gypsy moths resulted in substantial oak mortalities (approximately 22 trees per hectare). These mortalities were isolated in patches, resulting in little to no effect on seedling and sapling species composition. Also, Ehrenfeld (1977) found that 24 of the 94 species identified within park boundaries were non-native; a statistic much higher than documented in any other central New Jersey forest. These exotic species were primarily introduced for aesthetic purposes on plantations. The black locust (*Robinia pseudacacia*), an exotic species in New Jersey, is the most abundant tree in the park (Ehrenfeld 1982). This is likely due to the fact that farmers often plant this strong, hard, and durable tree as fence posts.

Current Land Use Practices

Presently, the majority of MORR is passively managed to maintain aesthetic and historical appearance, and to control exotic species. Each of the six fields used as sample sites in this project are mowed for vegetative control, promotion of wildlife use, aesthetic importance, and overflow parking. These fields are mowed on a frequency of once every two years to four times a year (Appendix 2). The wetland and woodland areas throughout the park are more passively managed. With the exception of minimal exotic plant removal (Japanese barberry (*Berberis thunbergii*) and oriental bittersweet (*Celastrus orbiculata*)), there is a hands-off policy towards the manipulations of habitats in the park, in order to allow the land to change and develop through natural processes (Bob Masson pers. comm.).

MORR currently exists as a habitat island in a suburbanized landscape. Change in land use and increased development has changed the character of the land surrounding the park from a once

rural landscape with rolling hills intersected by streams and wetlands to a developed residential area (NPS 1993).

Methods

Both general and targeted standardized survey methods were used in stream, wetland, and upland habitats. Multiple methods were often used in a given habitat because these habitats often support diverse amphibian and reptile species and require several methods to sample the entire herpetological community. While roads are not a "natural" habitat type for animals, the term was used to describe the location of species when they were observed crossing paved roads.

Site selection for standardized surveys was designed to sample across the range of habitat types available as well as be geographically encompassing (Table 1, Appendix 3, Figure 1). Based on existing maps of wetland and upland habitats, as well as field reconnaissance, all of the ponds/wetlands, streams, major seeps, rivers, field and woodland habitats were identified. Due to the park's relatively small size, the number of ponds/wetlands, streams, major seeps, and rivers were limited, such that all were sampled. Similarly, woodland habitat in the park was partitioned into six "sections" and all were sampled. For field habitat, of the 15 "fields" present, six sites were selected for sampling. Selection was based on size (larger preferred), degree to which a site was a field rather than a "lawn", adjacency to woodland/shrubland habitat, and a desire for sites to be "spread out".

Table 1. Overview of standardized survey sites and sampling methods used at each site.

Site	Habitat Type	Call Count	Egg Mass Count	TCS Pond	TCS Stream	TCS Field	TCS Woodland	Coverboard	Turtle Trap	Minnow Trap
Ephemeral Pond	temporary pond									X
Old Channel Pond	temporary pond	X		X						X
Lower Primrose Brook Seep	seep	X		X						X
Trail Center Seep	seep	X		X						X
Passaic River	river				X				X	
East Primrose Brook	permanent stream				X					
Lower Primrose Brook	permanent stream				X					
Lower West Primrose Brook	permanent stream				X					
Upper West Primrose Brook	permanent stream				X					
Cat Swamp Pond	permanent pond	X	X	X					X	X
Cattail Marsh	marsh	X		X						X
Indian Grave Brook Marsh	marsh	X		X						X
Jersey Brook	intermittent stream				X					
Jarvis Field	field					X		X		
MD Brigade Leach Field	field					X		X		
Mt. Kemble Field	field					X		X		
NY Brigade Leach Field	field					X		X		
Sugar Loaf Field	field					X		X		
Wick Farm North Field	field					X		X		
Woodland #1	deciduous forest						X	X		
Woodland #2	deciduous forest						X	X		
Woodland #3	deciduous forest						X	X		
Woodland #4	deciduous forest						X	X		
Woodland #5	deciduous forest						X	X		
Woodland #6	deciduous forest									

Incidental encounter locations represent specific points where animals were encountered outside of formal standardized surveys. The measure of a species' overall distribution was obtained by combining the number of standardized survey sites and incidental encounter locations at which it was recorded. This summed term is referred to as "localities". There were 45 localities. Of these, 12 were standardized survey sites, 13 were standardized survey sites at which incidental encounters occurred, and 20 were incidental encounter locations only.

Quantifying overall abundance was problematic due to the fact that each of the methods used provides a sample biased towards a particular species or group of species. However, because sampling effort was fairly evenly divided among the different methods and sampling biases were thus more or less compensated for, an overall measure of abundance for each species was derived by summing the number of adult form individuals (as opposed to eggs or larvae) encountered during each of the seven survey methods. For time-constrained search, coverboard checks, turtle and minnow trapping, and incidental encounters, the numbers of adults of a given species encountered during each sampling occasion were summed. Because amphibians were not marked for individual identification, for the purposes of quantifying overall abundance, reptiles were also treated as though they had not been marked. Because anuran call counts and egg mass counts do not directly count adults, the numbers of adults represented by these samples was estimated as follows. For egg mass counts, each egg mass represented the presence of one adult female. For anuran call counts, index values were converted to conservative estimates of the number of calling males present, based on data collected at Cape Cod National Seashore where both index values and estimates of numbers calling were made (Cook, unpublished data). Conservatively estimated numbers are as follows: Green Frog Index 1=2 males, Index 2= 8 males, Index 3 = 12 males; Bull Frog Index 1=2 males, Index 2 = 5 males; Grey Treefrog Index 1=3 males.

While these estimates are the best available of overall abundance, they are best interpreted not so much as absolute numbers but rather, as a reasonably accurate representation of ranked relative abundance and differences between species in the order of magnitude of their abundance.

Common and scientific names and spellings are those of Crother (2000) (Appendix 4). A Garmin III Plus Global Positioning System (GPS) unit was used to record the coordinates of each site surveyed during standardized surveys (Appendix 5) and location identified during incidental encounters (Appendix 6) were also recorded. GPS locality data were recorded as Universal Transverse Mercator (UTM) grid coordinates X=x-axis or Easting, and Y=y-axis or Northing, using NAD83. Given the low-impact nature of this study, voucher specimens of live animals were not collected.

Anuran Call Counts

Anuran call counts were conducted using the Wisconsin frog and toad survey method (Heyer et al. 1994) at six pond and wetland sites. Anuran call counts record the presence of species at specific sites and provide an index of abundance based on the calling intensity of species heard. Call index values and criteria for assigning them are; 0 = no calls, 1 = individuals can be counted, 2 = overlapping of calls, 3 = full chorus-calls are constant and individually indistinguishable. The surveyors arrived at each sample site at least one half-hour after dusk.

Researchers listened for anuran calls for five minutes, recording species heard, the number of individuals observed, if any, and the call index for each species.

Of the six anuran call count locations, 1 was surveyed twice, 1 three times, 1 five times, and 3 were surveyed seven times in the spring from 20 March – 7 June 2000. Because of the unequal number of surveys at each site, and the predominance of sampling in early spring, there is some bias against detecting species with low detection probabilities, as well as those that call later in the season. Multiple call counts at a site, conducted over the entire spring and early summer months are necessary to document species presence over time, as different anuran species are active at different times of the season (Conant and Collins 1998; Crouch and Paton 2002).

Survey sites were:

- Cat Swamp Pond
- Cattail Marsh
- Indian Grave Brook Marsh
- Lower Primrose Brook Seep
- Old Channel Pond
- Trail Center Seep

Egg-Mass Counts

Amphibians such as spotted salamanders (*Ambystoma maculatum*) and wood frogs (*Rana sylvatica*) migrate to ponds in the early spring to breed, depositing gelatinous egg masses. These masses are attached to fallen tree branches and vegetation in the water (Petranka 1998; Hunter et al. 1999). Egg-mass counts were conducted to record species presence and to document evidence of breeding by these and other pond-breeding amphibians (Albers and Prouty 1987; Mitchell 2000). One amphibian egg mass count was conducted on 17 April at Cat Swamp Pond. In counting egg masses, the entire pond was traversed, visually searching for egg masses, identifying and counting all egg masses observed and recording developmental stage and % mortality. While every effort was made to count all masses present in a pond, because spawning is only loosely synchronized, counts based on a single survey may underestimate total numbers of egg masses laid. Because only one egg mass count was conducted at one site, numbers of egg masses and species presence is likely underestimated.

Time-Constrained Search (TCS)

Habitat specific time-constrained search (TCS) was conducted in all habitats likely to support amphibians and reptiles, i.e., streams, woodlands, fields, and wetlands/ponds. Searches were conducted by moving through the habitat at a given site and searching under the best available cover (i.e., rocks, logs) favored by amphibians and reptiles (Bury and Raphael 1983), and by dip netting ponds (Heyer et al. 1994). An Index of Abundance (IA) for each species was calculated by dividing the total number of individuals recorded by the total search effort (person hours) spent for each search. Person hours are the total amount of time spent searching, multiplied by the number of people participating in the search.

Streams

Six stream sites were searched six to 14 times between 28 March and 25 September 2000. Total search time ranged from 5.9 to 27.7 search hours/stream (Appendix 7). Starting and ending times (Eastern Standard Time) and the number of people searching were recorded. Investigators systematically moved upstream, using a dip net in the stream to capture amphibians as rocks were overturned. Rocks, logs, and debris in the splash zone and on the bank were overturned and searched under. Identification and life stage (adult or larva) were recorded for each animal captured. The adult life stage was defined as any individual not in the larval stage and the larval stage, was defined as an individual with gills, showing pre-metamorphic characteristics.

Survey sites were:

- East Primrose Brook – Jockey Hollow Unit
- Jersey Brook – Jockey Hollow Unit
- Lower Primrose Brook – Jockey Hollow Unit, from confluence of West and East Primrose Brook, south to park boundary
- Lower West Primrose Brook – Jockey Hollow Unit, from Jockey Hollow Road, south to confluence with East Primrose Brook
- Passaic River – 0.5 mile segment within the New Jersey Brigade Unit
- Upper West Primrose Brook – Jockey Hollow Unit, segment north of Jockey Hollow Road

Woodlands

Six woodlands were searched five to seven times between 29 March and 25 September 2000. Total search time ranged from 10.2 to 15.9 search hours/site (Appendix 7). Start and end times, number of searchers, and the identification, number, and sex of individuals found were recorded.

Survey sites were:

- Woodland Section #1 – New Jersey Brigade Unit, west of the Passaic River
- Woodland Section #2 – New Jersey Brigade Unit, east of the Passaic River
- Woodland Section #3 – Jockey Hollow Unit, north of Jockey Hollow Road, west of Grand Parade Road
- Woodland Section #4 – Jockey Hollow Unit, north of Jockey Hollow Road, east of Grand Parade Road
- Woodland Section #5 – Jockey Hollow Unit, south of Jockey Hollow Road, west of Old Camp Road Trail
- Woodland Section #6 – Jockey Hollow Unit, south of Jockey Hollow Road, east of Old Camp Road Trail

Fields

Six fields were searched five times each between 14 April and 25 September 2000. Total search time ranged from 4.1 to 11.8 search hours/site (Appendix 7). Start and end times, number of searchers, and the identification, number, and sex of individuals found were recorded.

Survey sites were:

- Jarvis Field – 17.4 ha (42.9 ac) within New Jersey Brigade Unit
- Maryland Brigade Leach Field – 2.7 ha (6.7 ac) within Jockey Hollow Unit
- Mt. Kemble Field – 5.5 ha (13.5 ac) within Jockey Hollow Unit
- New York Brigade Leach Field – 0.3 ha (0.8 ac) within Jockey Hollow Unit
- Sugar Loaf Field – 0.7 ha (1.8 ac) within Jockey Hollow Unit
- Wick Farm North Field – 2.6 ha (6.4 ac) within Jockey Hollow Unit

Wetlands/Ponds

Six wetland and pond sites were searched one to seven times from 28 March and 22 September 2000. Total search time ranged from 1.0 to 7.1 search hours/site (Appendix 7). Searches were conducted after dusk, a time when amphibians are most active. Searches were conducted by traversing the entire pond when possible, sampling with a dip-net for amphibian larvae and adults, as well as turtles and snakes. Start and end times, number of searchers, and the identification, number and sex of individuals found were recorded.

Survey sites were:

- Cat Swamp Pond – Jockey Hollow Unit
- Cattail Marsh – Jockey Hollow Unit
- Indian Grave Brook Marsh
- Lower Primrose Brook Seep
- Old Channel Pond- New Jersey Brigade Unit, adjacent to Passaic River
- Trail Center Seep – Jockey Hollow Unit, parallel to Lower West Primrose Brook

Coverboards

Coverboards (Grant et al. 1992) were used primarily to inventory snakes. Coverboards located near wetlands were also expected to provide cover for terrestrial amphibians. Boards were 0.6m x 1.2m (2' x 4') and made of corrugated sheet metal or plywood. In March 2000, coverboards were deployed on top of vegetation at 6 field and 6 woodland sites. Six boards were placed five meters apart in linear "arrays" consisting of alternating wood and metal boards. One to two arrays were set at each survey site, depending on the size of the habitat area. Corn kernels were scattered under each coverboard in order to attract rodents and ultimately snakes. Coverboards were checked twice each month in April, May, and June and three times during August and September.

Field arrays were:

- Jarvis Field – two arrays
- Maryland Brigade Leach Field – one array
- Mt. Kemble Field – two arrays
- New York Brigade Leach Field – one array
- Sugar Loaf Field – one array
- Wick Farm North Field – one array

Woodland arrays were:

- Woodland #1 – one array
- Woodland #2 – one array
- Woodland #3 – one array
- Woodland #4 – one array
- Woodland #5 – two arrays
- Woodland #6 – two arrays

Capture rates (CR) were calculated as the number of snakes captured under boards divided by the total number of board checks for each site. Each time a board was checked constituted a "board check". Therefore, a site with 12 boards visited six times equaled 72 board checks.

The number of snakes captured per 100 coverboard checks were calculated as:

$$CR = \frac{(\text{\# of individual snakes captured})}{(\text{total \# of board checks})} \times 100$$

The effect of seasonality (April – June v. August – September) and coverboard type (wood v. sheet metal) on captures was tested using chi-square analysis (Sokal and Rohlf 1987).

Turtle Traps

Welded-wire crab traps measuring 30.5cm x 30.5cm x 60.1cm (12"x12"x 24"), with a mesh size of 1.3cm x 2.5cm (0.5" x 1"), were primarily used to sample shallow areas (along the bank of the Passaic River), for small aquatic/semi-aquatic turtles while funnel traps made of D-shaped metal hoops and 2.6cm (1") nylon mesh were used to sample deeper pond areas (Cat Swamp Pond) for aquatic turtles such as painted (*Chrysemys picta*) and snapping turtles (*Chelydra serpentina*) (Harless and Morlock 1989). Traps, baited with sardines in vegetable oil and checked daily, were set for weekly periods beginning on 18 April and ending on 21 May 2000 at the Passaic River and Cat Swamp Pond.
Each turtle was assigned a unique, individual identification number and, using a three-sided file, triangular notches were made on marginal scutes, to represent that number (Cagle 1939, Fig. 1).

Trap sites were:

- Passaic River (2 traps, first trapping date 18 April, last trapping date 21 May, 3 weekly trapping occasions, 26 total trap nights)
- Cat Swamp Pond (5 traps, first trapping date 9 May, last trapping date 21 May, 2 weekly trapping occasions, 45 total trap nights)

Minnow Traps

Wire mesh minnow traps measuring 15.2cm x 15.2cm x 30.5cm (6"x 6"x 12") were used to sample shallow pond areas for adult and larval salamanders, adult and larval anurans, and aquatic snakes (Heyer et al. 1994). One to four traps were deployed at seven sites for five-day periods from 17 March to 14 September 2000. Because this method primarily captures amphibians,

which were not marked for individual recognition, abundance was quantified as total captures (rather than unique individuals) per 100 trap nights.

Trap sites were:

- Cat Swamp Pond (3 traps, first trapping date 17 March, last trapping date 14 September, 99 total trap nights)
- Cattail Marsh (3 traps, first trapping date 17 March, last trapping date 14 August, 75 total trap nights)
- Ephemeral Pond (3 traps, first trapping date 20 March, last trapping date 17 April, 18 total trap nights)
- Indian Grave Brook Marsh (1 to 3 traps, first trapping date 20 March, last trapping date 14 September, 50 total trap nights)
- Lower Primrose Brook Seep (2 to 3 traps, first trapping date 17 March, last trapping date 14 September, 66 total trap nights)
- Old Channel Pond (3 traps, first trapping date 20 March, last trapping date 14 September, 93 total trap nights)
- Trail Center Seep (1 to 4 traps, first trapping date 17 March, last trapping date 14 September, 96 total trap nights)

Incidental Encounters

Any encounter with an amphibian or reptile not recorded as data in one of the standardized surveys was considered an incidental encounter. These were recorded on observation cards ("Green Cards") to augment data collected during formal surveys, and include observations made by park staff and visitors. For each incidental encounter, species, life stage, method of documentation, as well as location, habitat, and UTM coordinates were recorded, though some of these data were sometimes missing from visitor reports.

Data Storage

Data collected during the course of this study are stored on computer disk attached to this report. The original data sheets (Volumes I and II) are archived with the Northeast Temperate Inventory and Monitoring Network, Woodstock, Vermont..

Results

Overview of Park Herpetofauna

A total of 22 species, 13 amphibian and nine reptiles were recorded. Amphibians dominated the herpetofaunal community, accounting for 92% of the 2419 individuals recorded. By taxonomic group, anurans comprised 47.8% of all individuals, salamanders 44.6%, snakes 6.6%, and turtles 0.1%. The most abundant species in each taxonomic group, based on total numbers of adults recorded were northern green frog (*Rana clamitans melanota*), eastern red-backed salamander (*Plethodon cinereus*), eastern box turtle (*Terrapene carolina*), and eastern gartersnake (Table 2). One Stinkpot (*Sternothorus odoratus*), captured in the Passaic River, was a new record for the park, and four eastern milksnakes (*Lampropeltis t. triangulum*) were captured from Mt. Kemble Field.

Species were captured at 45 localities (25 standardized sample sites plus 20 incidental encounter locations) (Figs. 2, 3, 4, and 5). Based on Frequency of Occurrence, the most widespread species in each taxonomic group was northern green frog and American toad (*Bufo americanus*) (16 or 35.6% of all localities), eastern red-backed salamander (14 or 31.1%), eastern box turtle (6 or 13.3%), and eastern gartersnake (16 or 35.6%) (Table 3).

By habitat, relative abundance (number of adults) was greatest in wetland (50% of individuals recorded), followed by stream (29%), and upland (21%) (Table 2). Conversely, species richness was greatest in uplands (16 species), followed closely by 15 species in stream habitats, and 14 in wetlands (Table 2). Within the nine sub-habitat categories, species richness was greatest in permanent ponds (11 species, 50% of recorded species), in river (11 species), and in deciduous forest (10 species). In addition, eight species were recorded on roads (Table 2).

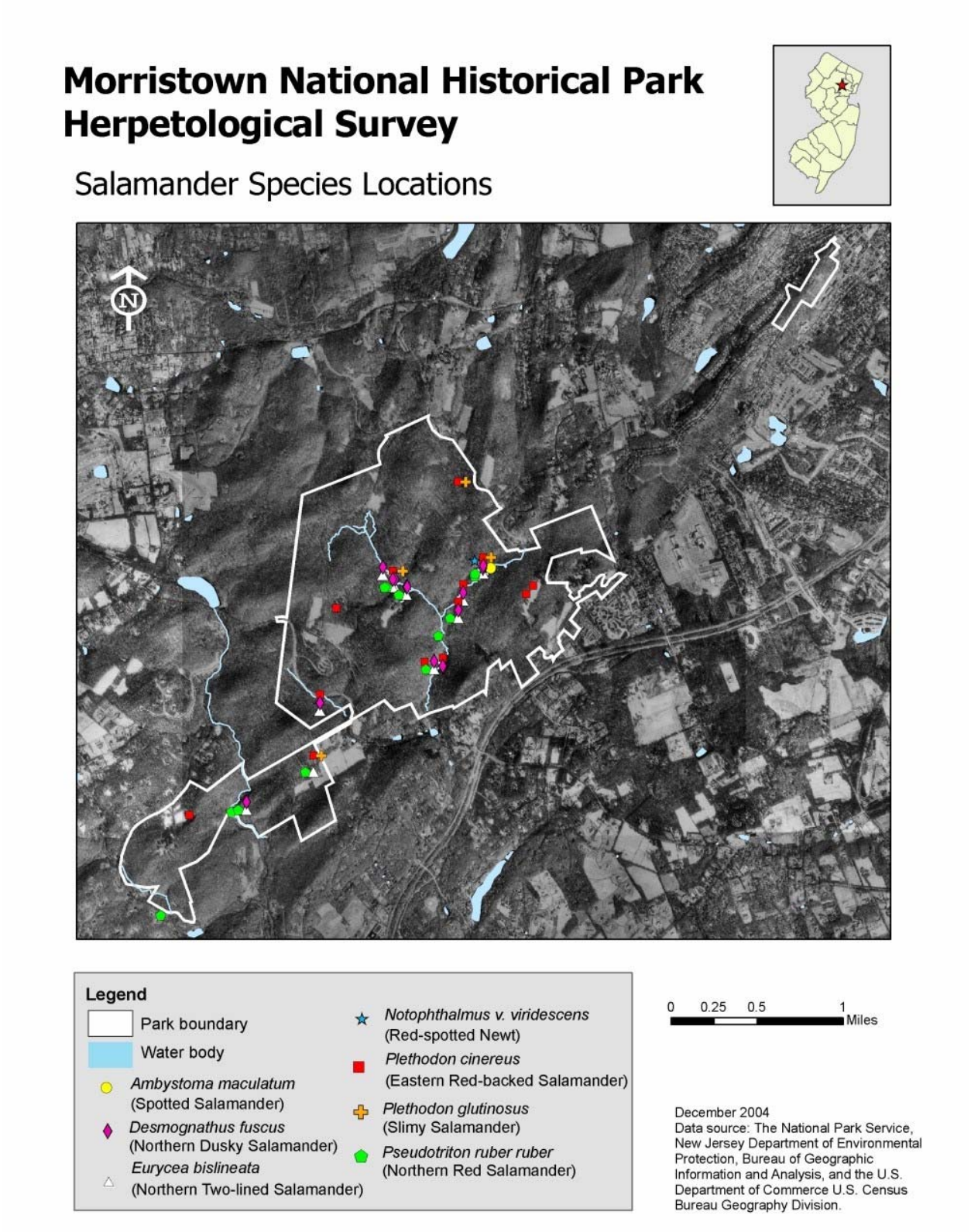

Figure 2. Location of salamander species detected in Morristown National Historical Park in 2000.

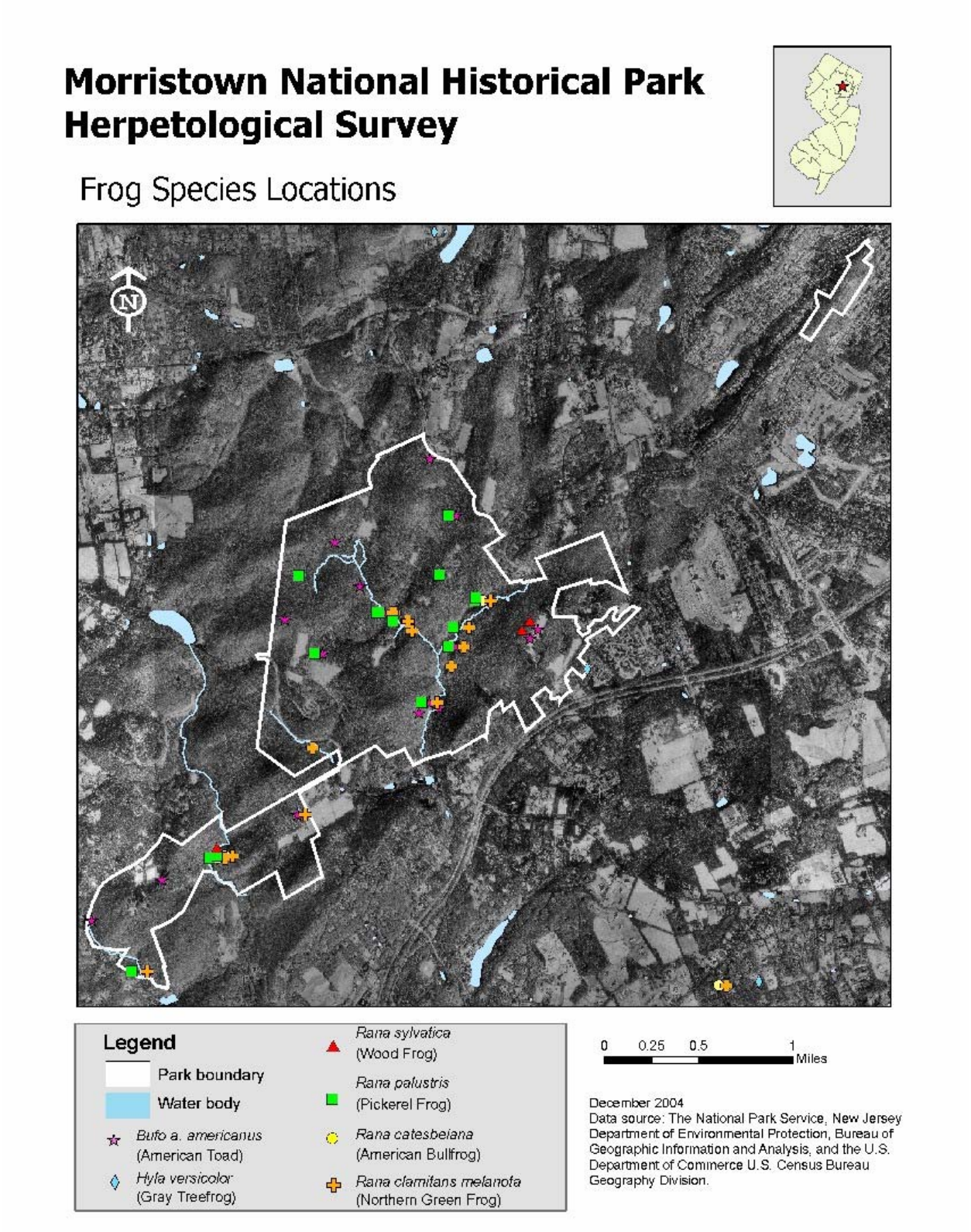

Figure 3. Location of frog species detected in Morristown National Historical Park in 2000.

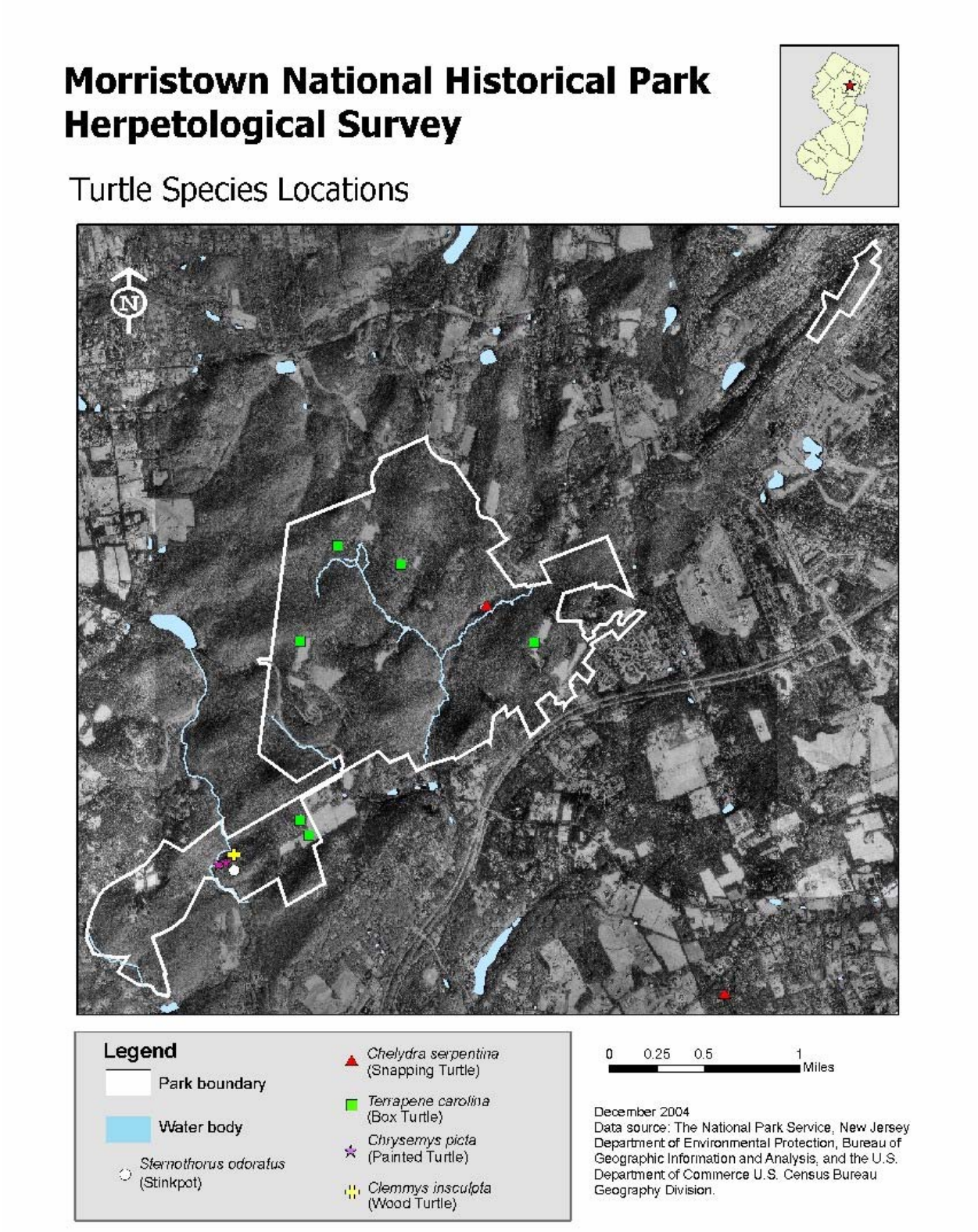

Figure 4. Location of turtle species detected in Morristown National Historical Park in 2000.

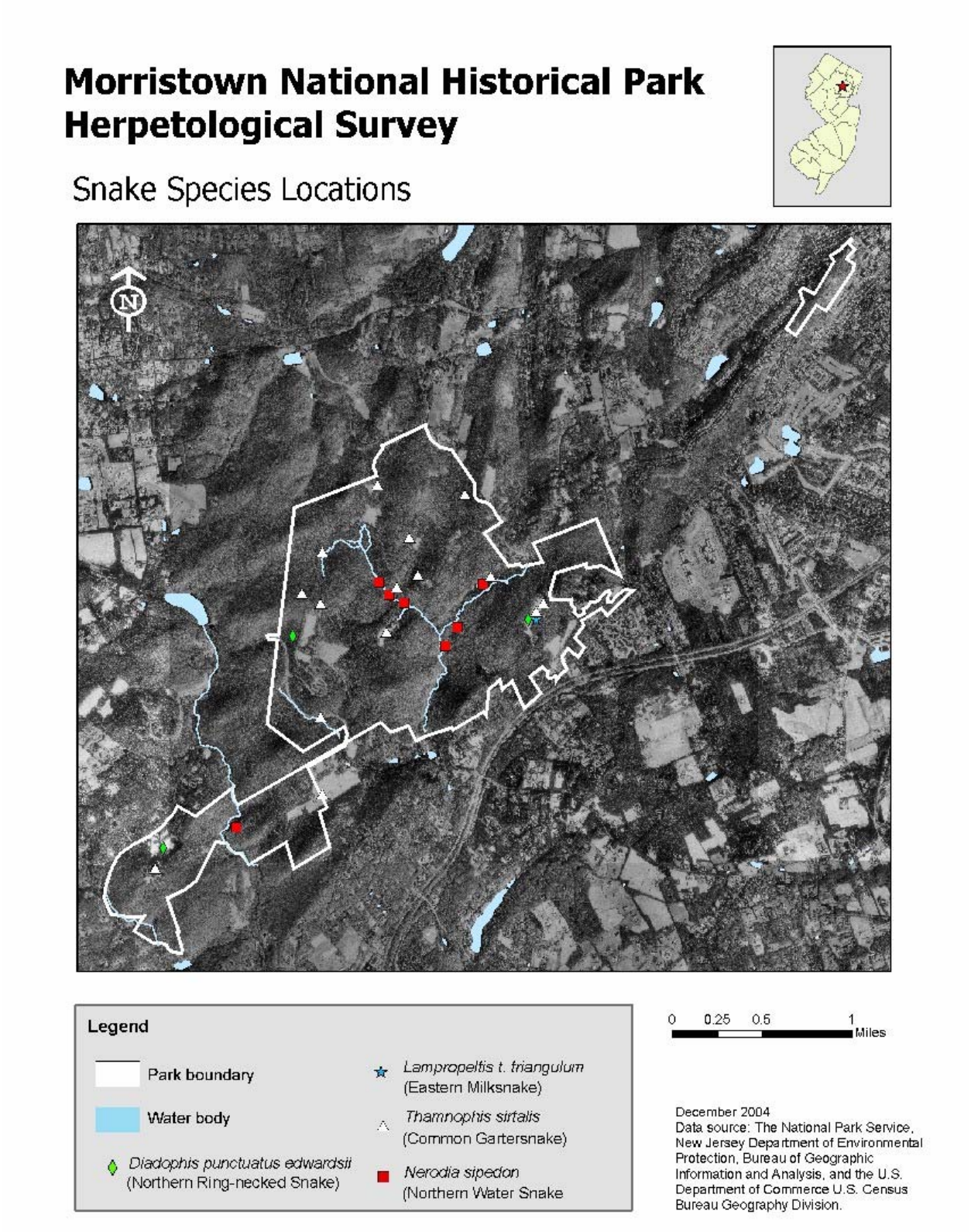

Figure 5. Location of snake species detected in Morristown National Historical Park in 2000.

Table 2. Number of adult amphibians and reptiles encountered during all surveys by habitat category in Morristown National Historical Park, March to September 2000. Relative Abundance (RA) is number of individuals/species divided by total number of adults of all species (n=2419), multiplied by 100.

	Number of Adults Recorded by Habitat Category											
Species	**Stream**			**Wetland**				**Upland**			**Total**	**RA(%) (Rank)**
	int.	**perm.**	**river**	**seep**	**marsh**	**perm. pond**	**temp. pond**	**decid. forest**	**field**	**road**		
FROGS												
Northern Green Frog	6	25	9	43	23	446	65	5		3	625	25.84 (1)
Pickerel Frog		15	8	19	46	333	2	5	3	1	432	17.86 (2)
American Bullfrog			1			45	2			5	53	2.19 (8)
American Toad		2		1	1			4	10	8	26	1.07 (9)
Gray Treefrog										15	15	0.62 (11)
Wood Frog			1						4		5	0.21 (15)
SALAMANDERS												
Eastern Red-backed Salamander	1	47		2	1	26		307	7		391	16.16 (3)
Northern Two-lined Salamander	14	179	108		3			3			307	12.69 (4)
Northern Dusky Salamander	18	188	36	4	4	1		3			254	10.50 (5)
Red-spotted Newt						89					89	3.68 (6)
Northern Red Salamander		9	4	1	4	1	2	4			25	1.03 (10)
Northern Slimy Salamander		1						7			8	0.33 (13)
Spotted Salamander						6					6	0.25 (14)
TURTLES												
Eastern Box Turtle								1	12	2	15	0.62 (11)
Snapping Turtle						2				1	3	0.12 (17)
Painted Turtle			1				1				2	0.08 (18)
Wood Turtle			2								2	0.08 (18)
Stinkpot			1								1	0.04 (19)
SNAKES												
Eastern Gartersnake	4				1	2		1	51	30	89	3.68 (6)
Northern Watersnake		5	6	2	2	39					54	2.23 (7)
Northern Ring-necked Snake									13		13	0.54 (12)
Eastern Milksnake									4		4	0.17 (16)
TOTAL # ADULTS	**43**	**471**	**177**	**72**	**85**	**990**	**72**	**340**	**104**	**65**	**2419**	
TOTAL # SPECIES	**5**	**9**	**11**	**7**	**9**	**11**	**5**	**10**	**8**	**8**	**22**	
	15			**14**				**16**				

Table 3. Distribution by habitat category of the 22 species of amphibians and reptiles recorded in Morristown National Historical Park, March to September 2000. Based on number of localities at which a species was recorded. Frequency of Occurrence (FO) is number of localities a species was recorded from divided by total number (45). Number of localities includes both standardized survey sites and incidental encounter locations.

	Number of Localities Recorded by Habitat Category											
Species	**Stream**			**Wetland**				**Upland**			**Total**	**FO (%)**
	int.	**perm.**	**river**	**seep**	**marsh**	**perm. pond**	**vernal pond**	**decid. forest**	**field**	**road**		
FROGS												
Northern Green Frog	1	5	1	2	2	1	1	1		2	16	35.6
American Toad		2		1	1			5	4	3	16	35.6
Pickerel Frog		4	1	1	2	1	1	3	1	1	15	33.3
American Bullfrog			1			1	1			1	4	8.9
Gray Treefrog										3	3	6.7
Wood Frog			1						2		3	6.7
SALAMANDERS												
Eastern Red-backed Salamander	1	2		1	1	1		6	2		14	31.1
Northern Dusky Salamander	1	6	1	2	1	1		1			13	28.9
Northern Red Salamander		4	1	2	2	1	1	2			13	28.9
Northern Two-lined Salamander	1	6	1		1			2			11	24.4
Northern Slimy Salamander		1						3			4	8.9
Red-spotted Newt						1					1	2.2
Spotted Salamander						1					1	2.2
TURTLES												
Eastern Box Turtle								1	3	2	6	13.3
Snapping Turtle						1				1	2	4.4
Painted Turtle			1				1				2	4.4
Wood Turtle			1								1	2.2
Stinkpot			1								1	2.2
SNAKES												
Eastern Gartersnake	1				1	1		1	8	4	16	35.6
Northern Watersnake		2	1	2	1	1					7	15.6
Northern Ring-necked Snake									4		4	8.9
Eastern Milksnake									1		1	2.2
TOTAL # OF LOCALITIES	**1**	**6**	**1**	**3**	**3**	**1**	**2**	**6**	**13**	**11**	**45**	

Survey Method Summaries

Incidental encounters detected 18 of the 22 species recorded (Tables 4 and 5) and accounted for more individuals than any other method (41% of all adult form individuals recorded). For 10 species, it was the most productive method (i.e., produced the greatest number of individuals) (Table 6). Of the standardized surveys, Stream TCS and Woodland TCS produced the greatest number of species (10 each). Stream TCS produced 24% of all individuals recorded, and was the most productive method for northern two-lined salamander (*Eurycea bislineata*). Wetland TCS recorded nine species, 13% of all individuals recorded. Minnow traps recorded six species, 4% of all individuals recorded, and was the most productive method for two species (red-spotted newt (*Notophthalmus v. viridescens*) and spotted salamander). Coverboards produced five species, 2% of all individuals recorded, and was the most productive method for northern slimy salamander (*Plethodon glutinosus*), northern ring-necked snake (*Diadophis punctuatus edwarsii*), and eastern milksnake. Field TCS recorded three species, 1% of all individuals recorded, and was the most productive method for eastern box turtle (67% of all box turtles found). Turtle traps produced 2 species, 1% of all individuals recorded, and captured the first record of a stinkpot turtle in the park. Amphibian call counts and egg-mass counts each recorded one species, accounted for 1% of all individuals recorded, and because of limited sampling, were not very productive.

Table 4. Number of amphibians recorded by each survey method in Morristown National Historical Park from March to September, 2000. Survey methods are: ACC=Anuran Call Count; EMC=Egg Mass Count; TCS=Time Constrained Search; CB=Coverboard; TT=TurtleTrap; MT=Minnow Trap; and IE=Incidental Encounter. Life stage of animals is: A=Adult; L=Larvae; E=Egg; VOC=calling anurans.

Survey Method	**Amphibians**																								
	Northern Green Frog				**Pickerel Frog**			**American Bullfrog**			**American Toad**	**Gray Treefrog**	**Wood Frog**	**Eastern Red-backed Salamander**	**Northern Two-lined Salamander**		**Northern Dusky Salamander**		**Red-spotted Newt**	**Northern Red Salamander**		**Northern Slimy Salamander**	**Spotted Salamander**		**# of Amphibian Species**
	A	L	E	VOC	A	L	E	A	L	VOC	A	VOC	A	A	A	L	A	L	A	A	L	A	A	L	
ACC[1]	4																								1
EMC[2]							30																		1
TCS-stream	27				17			1					1		282	13	229	64		9	21	1			8
TCS-woodland	5				5						3			307	3		3			4		3			8
TCS-field					1									5											2
TCS-wetland	108	710		2	124	14	6	14							1			4	42	2	1				7
CB											1											4			2
TT																									0
MT	28	280			16	52			2								1	1	45	3	20		6	6	7
IE[3]	399	278	16	36	198		35	33		5	22	15	4	79	21	3	21	1	2	7	5				11
Total	**571**	**1268**	**16**	**38**	**361**	**66**	**71**	**48**	**2**	**5**	**26**	**15**	**5**	**391**	**307**	**16**	**254**	**70**	**89**	**25**	**47**	**8**	**6**	**6**	**13**

[1]Amphibian Call Count numbers (A), TCS and IE VOC numbers represent the estimated number of males calling.
[2] E=estimated number of adult females based on number of egg masses; 1 egg mass=1 adult female.
[3] The adult stage for Incidental Encounters represents adults and juveniles.

Table 5. Number of reptiles recorded by each survey method in Morristown National Historical Park from March to September, 2000. Survey methods are: TCS=Time Constrained Search; CB=Coverboard; TT=TurtleTrap; MT=Minnow Trap; and IE=Incidental Encounter.

Survey Method	Reptiles									
	Eastern Gartersnake	Northern Watersnake	Northern Ring-necked Snake	Eastern Milksnake	Eastern Box Turtle	Snapping Turtle	Painted Turtle	Wood Turtle	Stinkpot	# of Reptilian Species
TCS-stream	1	5								2
TCS-woodland	1				1					2
TCS-field	7				10					2
TCS-wetland	1	2					1			3
CB	34		11	4						3
TT							1		1	2
MT		5								1
IE	45	42	2		4	3		2	1*	7
Total	**89**	**54**	**13**	**4**	**15**	**3**	**2**	**2**	**1**	**9**

*this was the same Stinkpot captured during turtle trapping

Table 6. Percentage of adult form individuals of each species detected by each survey method. Derived from Tables 4 and 5.

	Northern Green Frog	Pickerel Frog	American Bullfrog	American Toad	Gray Treefrog	Wood Frog	Eastern Red-backed Salamander	Northern Two-lined Salamander	Northern Dusky Salamander	Red-spotted Newt	Northern Red Salamander	Northern Slimy Salamander	Spotted Salamander	Eastern Box Turtle	Snapping Turtle	Painted Turtle	Wood Turtle	Stinkpot	Eastern Gartersnake	Northern Watersnake	Northern Ring-necked Snake	Eastern Milksnake	Total # Inds	%Total Inds	#Spp
ACC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	1
EMC	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	1	1
TCS Stream	4	4	2	0	0	20	0	92	90	0	36	13	0	0	0	0	0	0	1	9	0	0	573	24	10
TCS Woodland	1	1	0	11	0	0	79	1	1	0	16	38	0	7	0	0	0	0	1	0	0	0	335	14	10
TCS Field	0	1	0	0	0	0	1	0	0	0	0	0	0	67	0	0	0	0	8	0	0	0	23	1	4
TCS Wetland	18	30	26	0	0	0	0	1	0	47	8	0	0	0	0	50	0	0	1	4	0	0	304	13	9
CB	0	0	0	4	0	0	0	0	0	0	0	50	0	0	0	0	0	0	38	0	85	100	54	2	5
TT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	50	0	0	0	0	2	1	2
MT	4	4	0	0	0	0	0	0	0	51	12	0	100	0	0	0	0	0	0	9	0	0	104	4	6
IE	72	54	72	85	100	80	20	7	9	2	28	0	0	27	100	0	100	50	51	78	15	0	991	41	18
%Total Inds	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		100	
Total # Inds	625	432	53	26	15	5	391	307	254	89	25	8	6	15	3	2	2	1	89	54	13	4	2419		22

Anuran Call Counts

Northern green frog was the only anuran heard calling during 32 call counts conducted at six survey sites (Table 7). This species was heard during two separate call counts at Cat Swamp Pond on 19 May and 7 June 2000. Based on call count index values, these calls represented four individuals.

Table 7. Species richness and the highest call index identified for anurans during amphibian-call counts from 20 March to 7 June 2000 in Morristown National Historical Park.

Site	**Start Date**	**End Date**	**# of Visits**	**Species**	**Call Index**	**# of Encounters**	**# of Species**
Cat Swamp Pond	20-Mar	07-Jun	7	Northern Green Frog	1	2	**1**
Cattail Marsh	20-Mar	07-Jun	7	NONE	0	0	**0**
Indian Grave	20-Mar	30-Mar	2	NONE	0	0	**0**
Lower Primrose	20-Mar	19-May	3	NONE	0	0	**0**
Old Channel Pond	20-Mar	07-Jun	5	NONE	0	0	**0**
Trail Center Seep	20-Mar	07-Jun	7	NONE	0	0	**0**

Egg-Mass Counts

Cat Swamp Pond was the only site surveyed during egg-mass counts. These counts, conducted on 17 April recorded 30 pickerel frog (*Rana palustris*) egg masses, and represent 30 adult females.

Time-Constrained Search (TCS)

Stream TCS

Ten species were detected during TCS in six streams. The northern green frog, northern two-lined salamander and northern dusky salamander (*Desmognathus fuscus*) were the most widespread species, recorded from all streams surveyed. These were followed by pickerel frog and northern red salamander (*Pseudotriton r. ruber*), each recorded from 67% of streams, and common watersnake (*Nerodia sipedon*), northern slimy salamander, American bullfrog (*Rana catesbeiana*), wood frog, and eastern gartersnake, each recorded from 17% of streams (Table 8). The northern two-lined salamander was the most abundant species, with an Index of Abundance (IA) of 3.41 individuals/search hour. Northern dusky salamanders were the second most abundant species (IA=2.77). Northern slimy salamander, American bullfrog, wood frog, and eastern gartersnake were the least abundant (IA=0.01 for each) (Table 8). The Passaic River had the greatest species richness with eight species and was the only stream site to record northern watersnake, northern slimy salamander, American bullfrog, wood frog, and eastern gartersnake.

Table 8. Number of amphibians and reptiles identified during stream time-constrained surveys in Morristown National Historical Park, 28 March to 25 September 2000. The Index of Abundance (IA) is number of individuals divided by total search effort.

Site (search hrs)	Species # (IA)																# of Species[1]
	Northern Two-lined Salamander		Northern Dusky Salamander		Northern Green Frog	Pickerel Frog	Northern Red Salamander		Northern Watersnake	Northern Slimy Salamander	American Bullfrog	Wood Frog	Eastern Gartersnake	Unknown Salamander Spp.	Unknown Frog Spp.	Unknown Snake Shed	
	Adult	Larvae	Adult	Larvae	Adult	Adult	Adult	Larvae	Adult	Adult	Adult	Adult	Adult	SAL	FROG	SHD	
East Primrose Brook (12.7)	27 (2.13)	2 (0.16)	29 (2.28)	17 (1.34)	4 (0.31)	8 (0.63)								6 (0.47)			**4**
Jersey Brook (5.9)	14 (2.37)		18 (3.05)	8 (1.36)	6 (1.02)								1 (0.17)	1 (0.17)	3 (0.51)		**4**
Lower Primrose Brook (11.7)	38 (3.25)	1 (0.09)	44 (3.76)	7 (0.60)	3 (0.26)	1 (0.09)	4 (0.34)	3 (0.26)						2 (0.17)			**5**
Lower West Primrose (12.0)	43 (3.58)	6 (0.50)	44 (3.67)	6 (0.50)	3 (0.25)	-	1 (0.08)	3 (0.25)						5 (0.42)	1 (0.08)		**4**
Passaic River (27.7)	101 (3.65)	3 (0.11)	34 (1.23)	12 (0.43)	9 (0.32)	7 (0.25)	1 (0.04)	7 (0.25)	5 (0.18)		1 (0.04)	1 (0.04)		1 (0.04)		1 (0.04)	**8**
Upper West Primrose (12.0)	59 (4.92)	1 (0.08)	60 (5.00)	14 (1.17)	1 (0.08)	1 (0.08)	3 (0.25)	8 (0.67)		1 (0.08)				4 (0.33)	1 (0.08)		**6**
Total	**282**	**13**	**229**	**64**	**26**	**17**	**9**	**21**	**5**	**1**	**1**	**1**	**1**	**19**	**5**	**1**	**10**
IA[2]	**3.41**	**0.16**	**2.77**	**0.77**	**0.31**	**0.21**	**0.11**	**0.25**	**0.06**	**0.01**	**0.01**	**0.01**	**0.01**	**0.23**	**0.06**	**0.01**	

[1]Does not include unknown species
[2]Based on 82.8 total search hours

Woodland/Field TCS

Ten species were detected during woodland TCS in six areas. The eastern red-backed salamander was the most widespread species, recorded in all six areas surveyed, followed by pickerel frog, American toad, northern slimy salamander (50% of areas), northern red salamander, and northern two-lined salamander (33% of areas), and northern green frog, northern dusky salamander, eastern box turtle, and eastern gartersnake (17% of areas) (Table 9). The red-backed salamander was also the most abundant species (IA=4.14), and the eastern box turtle and eastern gartersnake were the least abundant (IA=0.01 for each) (Table 9). Woodland TCS area #2 had the greatest species richness with seven species recorded and also the greatest number of animals recorded (25% of individuals) (Table 9).

Four species were detected during field TCS in six areas. The eastern box turtle and eastern gartersnake were the most widespread species, each recorded in three areas surveyed (50%), followed by eastern red-backed salamander and pickerel frog (17% of areas) (Table 9). The eastern box turtle was also the most abundant species (IA=0.23) and pickerel frog was the least abundant (IA=0.02). Jarvis Field and Mt. Kemble Field had the greatest species richness with two species recorded at each (Table 9). Woodland TCS was generally more productive (10 species, IA=4.5) than field TCS (4 species, IA=0.6), but eastern box turtle and eastern gartersnakes were more abundant in fields.

Table 9. Number of amphibians and reptiles recorded during field and woodland time-constrained surveys in Morristown National Historical Park, 29 March to 25 September 2000. The Index of Abundance (IA) is number of individuals divided by total search effort.

HABITAT CATEGORY	Site (search hours)	Species #(IA)										Total	# of Species
		Pickerel Frog American Toad	Northern Green Frog	Eastern Red-backed Salamander	Northern Red Salamander	Northern Dusky Salamander	Northern Two-lined Salamander	Northern Slimy Salamander	Eastern Box Turtle	Eastern Gartersnake			
FIELD	Jarvis Field (11.8)								6 (0.51)	5 (0.42)		**11 (0.93)**	**2**
	Maryland Brigade Field (5.0)									1 (0.20)		**1 (0.02)**	**1**
	Mt. Kemble Field (10.9)			5 (0.46)					2 (0.18)			**7 (0.64)**	**2**
	NY Brigade Leach Field (4.1)	1 (0.24)										**1 (0.24)**	**1**
	Sugar Loaf Field (5.6)									1 (0.18)		**1 (0.18)**	**1**
	Wick Farm North (6.1)								2 (0.33)			**2 (0.33)**	**1**
	Total (IA)[1]	**1 (0.02)**	**0**	**5 (0.11)**	**0**	**0**	**0**	**0**	**10 (0.23)**	**7 (0.16)**		**26 (0.6)**	**4**
WOODLAND	Woodland #1 (10.9)			24 (2.20)								**24 (2.20)**	**1**
	Woodland #2 (15.9)	1 (0.06)	5 (0.31)	72 (4.53)	3 (0.19)		2 (0.13)	1 (0.06)	1 (0.06)			**85 (5.35)**	**7**
	Woodland #3 (11.2)	1 (0.09)		18 (1.61)								**20 (1.79)**	**3**
	Woodland #4 (12.3)	1 (0.08)		55 (4.47)				1 (0.08)		1 (0.08)		**58 (4.72)**	**4**
	Woodland #5 (13.7)	1 (0.07)		75 (5.47)								**76 (5.55)**	**2**
	Woodland #6 (10.2)	3 (0.03)		63 (0.63)	1 (0.01)	3 (0.03)	1 (0.01)	1 (0.01)				**72 (0.72)**	**6**
	Total (IA)[2]	**5 (0.07)**	**3 (0.04)**	**307 (4.14)**	**4 (0.05)**	**3 (0.04)**	**3 (0.04)**	**3 (0.04)**	**1 (0.01)**	**1 (0.01)**		**335 (4.5)**	**10**

[1]based on 43.5 total search hours
[2]based on 74.2 total search hours

Wetland/Pond TCS

Ten species were detected during wetland/pond TCS at six sites. Permanent pond TCS at Cat Swamp Pond found 6 species, all of which were more abundant than in temporary wetlands. Red-spotted newt, American bullfrog, northern watersnake, and eastern gartersnake were found in Cat Swamp Pond and not in temporary wetlands surveyed. The northern green frog was the most widespread species from both permanent and temporary wetland TCS, recorded at five of six (83.3%) sites surveyed, followed by pickerel frog (33% of sites), and red-spotted newt, American bullfrog, northern dusky salamander, northern watersnake, northern red salamander, painted turtle, northern two-lined salamander, and eastern gartersnake (17% of sites) (Table 10). Pickerel frog was the most abundant species in permanent pond TCS (IA=15.8), and the northern green frog was nearly as abundant (IA=10.0). Northern green frog was the most abundant species in temporary pond TCS (IA=1.97). Northern dusky salamander, northern red salamander, and painted turtle were found in temporary pond TCS but not in permanent pond TCS (Table 10). No species were recorded from Lower Primrose Brook Seep (Table 10).

Table 10. Number of amphibians and reptiles recorded during wetland/pond time-constrained surveys in Morristown National Historical Park, 28 March to 22 September 2000. The Index of Abundance (IA) is number of individuals divided by search effort.

HYDROPERIOD	Site (search hrs)	Species #(IA)																# of Spp
		Pickerel Frog			Northern Green Frog			Red-spotted Newt	American Bullfrog	Northern Dusky Salamander	Ranid species	Northern Watersnake	Northern Red Salamander		Painted Turtle	Northern Two-lined Salamander	Eastern Gartersnake	
		Adl	Egg	Lrv	Adl	Lrv	Voc	Adl	Adl	Lrv	Lrv	Adl	Adl	Lrv	Adl	Adl	Shed	
PERMANENT	Cat Swamp Pond (7.1)	112	6	14	71	707	2	42	14		4	2					1	**6**
	Total (IA)[1]	**112 (15.8)**	**6 (0.85)**	**14 (1.97)**	**71 (10.00)**	**707 (99.57)**	**2 (0.28)**	**42 (5.92)**	**14 (1.97)**		**4 (0.56)**	**2 (0.28)**					**1 (0.14)**	**6**
TEMPORARY	Cattail Marsh(6.1)	12 (1.97)			5 (0.82)											1 (0.16)		**3**
	Indian Grave Bk Marsh(1.9)				1 (0.53)													**1**
	Lower Primrose Bk Seep(1.0)																	**0**
	Old Channel Pond (5.1)				29 (5.69)								2 (0.39)	1 (0.20)	1 (0.20)			**3**
	Trail Center Seep (6.1)				3 (0.49)					4 (0.66)								**2**
	Total (IA)[2]	**12 (0.62)**			**38 (1.97)**					**4 (0.21)**			**2 (0.10)**	**1 (0.05)**	**1 (0.05)**	**1 (0.05)**		**6**

[1]Based on 7.1 total person hours
[2]Based on 19.3 total person hours

Coverboards

Forty-nine snakes of three species were captured under 17 (11%) coverboards at 4 sites (Table 11). Coverboards in fields accounted for all snake captures, none were found under coverboards in six woodland sites. Eastern gartersnake was the most widespread species, recorded at 33% (4/12) of coverboard sites, followed by northern ring-necked snake (17%, 2/12) eastern milksnake, slimy salamander, and American toad (8%, 1/12) of sites. Based on number of individuals and capture rate (CR), the eastern gartersnake was also the most abundant snake species (n=34 individuals, CR=3.12), followed by northern ring-necked snake (n=11, CR=1.01), and eastern milksnake (n=4, CR=0.37) (Table 11). Wick Farm North Field and Mt. Kemble Field had the greatest species richness with three species each and Wick Farm North Field had the greatest number of snakes (n=26). The eastern milksnake was only captured at Mt. Kemble Field. All four individuals were captured under plywood boards in September.

Slightly more coverboard checks occurred during August and September (53%). The seasonal differences in numbers captured (24 vs. 25 snakes) were not significant (χ^2=0.82, p<0.77) (Table 12). Also, captures were not significantly higher under metal (53%) versus wood (47%) coverboards (χ^2=0.18, p<0.67) (Table 13).

Table 11. Number of amphibians and reptiles recorded during field and woodland coverboard surveys in Morristown National Historical Park, 24 April to 25 September 2000. Capture Rate (CR) is number of snakes captured/100 board checks. Board checks are number of boards per site, multiplied by number of site visits.

HABITAT	Sites	Number of Amphibians and Reptiles									# of Boards per Site[1]	# of Site Visits	# of Board Checks	# of Boards with Snakes
		E. Garter-snake	**N. Ring-necked Snake**	**E. Milk-snake**	**Slimy Sal.**	**Un-known species**	**Amer. Toad**	**# Snakes**	**# Spp**	**CR**				
FIELD	Jarvis Field	5 (3.78)						5	1	**3.78**	12	12	132	**3**
	MD Brigade Field							0	0	**0**	6	12	66	**0**
	Mt. Kemble Field	8 (6.06)	3 (2.27)	4 (3.03)				15	3	**11.36**	12	12	132	**8**
	NY Brigade Leach Field							0	0	**0**	6	13	72	**0**
	Sugar Loaf Field	3 (4.17)				1 (1.39)		3	2	**4.17**	6	13	72	**1**
	Wick Farm North Field	18 (23.08)	8 (10.26)			1 (1.28)		26	3	**33.33**	6	14	78	**5**
	Total (CR)	**34 (6.16)**	**11 (1.99)**	**4 (0.72)**	**0**	**2 (0.36)**	**0**	**49**	**3**	**8.88**			**552**	**17**
WOODLAND	Woodland #1							0	0	**0**	6	11	63	**0**
	Woodland #2							0	0	**0**	6	12	66	**0**
	Woodland #3					1 (1.39)		0	1	**0**	6	13	72	**0**
	Woodland #4						1 (1.52)	0	1	**0**	6	12	66	**0**
	Woodland #5							0	0	**0**	12	13	132	**0**
	Woodland #6				4 (2.90)			0	1	**2.90**	12	14	138	**0**
	Total (CR)	**0**	**0**	**0**	**4 (0.74)**	**1 (0.19)**	**1 (0.19)**	**0**	**2**	**0**			**537**	**0**
	Total	**34**	**11**	**4**	**4**	**3**	**1**	**49**	**5**	**5.2**	**96**	**151**	**1089**	**17**
	Overall CR	**3.12**	**1.01**	**0.37**	**0.37**	**0.28**	**0.09**							

[1] sites had only 3 to 6 boards during the first board checks, up to 12 boards were added for subsequent board checks

Table 12. Seasonal variation in snake captures during coverboard surveys in Morristown National Historical Park, April to June versus August to September 2000. Board checks are the number of boards per site, multiplied by the number of site visits.

Dates	Number (%) of Board Checks	**Number of Board Checks Producing Snakes**	**Percent of Board Checks Producing Snakes**	**Number (%) of Snakes**
April – June	513 (47%)	19	3.7%	24 (49%)
August – September	576 (53%)	21	3.6%	25 (51%)
Total	**1089**	**40**	**3.7%**	**49**

Table 13. Number of snakes captured under metal versus plywood during coverboard surveys in Morristown National Historical Park, 24 April to 25 September 2000.

Species	**Number of Snakes**	**Coverboard Type**			
		Metal[1]		**Plywood**[1]	
		# of Snakes	**% of Snakes**	**# of Snakes**	**% of Snakes**
Eastern Gartersnake	34	20	59%	14	41%
Northern Ring-necked Snake	11	3	27%	8	73%
Eastern Milksnake	4	0	0%	4	100%
All Snakes	**49**	**23**	**47%**	**26**	**53%**

[1]Total of 48 metal and 48 wood coverboards

Turtle Traps

One painted turtle and one stinkpot were trapped from the Passaic River. The stinkpot was recaptured four more times after initial capture. No turtles were trapped in Cat Swamp Pond. Due to limited trap effort, the Index of Abundance and Chapman's modified Lincoln Petersen Index values provide limited information on the status of these species at these trap sites. While trapping confirmed the presence of a painted and stinkpot turtle in the Passaic River, further trapping may be needed to determine their abundance.

Minnow Traps

Eight species were detected using minnow traps. Permanent pond trapping was conducted at Cat Swamp Pond, the only permanent pond in the park. Trapping here was more productive (6 species) than temporary pond trapping (5 species), and Ephemeral Pond was the least productive (0 species). Northern green frog was the most abundant larvae from Cat Swamp Pond (IA=279.80), and red-spotted newt was the most abundant adult form (IA=45.45). Red-spotted newt, spotted salamander, and American bullfrog were found in Cat Swamp Pond and not found in temporary wetlands. Conversely, northern red and northern dusky salamanders were found in temporary wetlands and were not found in Cat Swamp Pond (Table 14). Northern green frog was the most widespread, recorded at six of seven (86%) minnow trap sites followed by northern red salamander (71% of sites), northern watersnake (57%), pickerel frog (43%), red-spotted newt, spotted salamander, northern dusky salamander, and American bullfrog (14% of sites) (Table 14).

Table 14. Number of amphibians and reptiles captured during minnow trapping in Morristown National Historical Park, 17 March to 14 September 2000. Index of Abundance (IA) is number of individuals captured per 100 trap nights.

HYDROPERIOD	Site (trap nights)	Species #(IA)													# of Spp
		Red-spotted Newt	Northern Green Frog		Pickerel Frog		Spotted Salamander		Northern Watersnake	Northern Red Salamander		Northern Dusky Salamander		American Bullfrog	
		Adl	Adl	Lrv	Adl	Lrv	Adl	Lrv	Adl	Adl	Lrv	Adl	Lrv	Lrv	
PERMANENT	Cat Swamp Pond[1] (99)	45	2	277	14	52	6	6	1					2	**6**
	Total (IA)	**45 (45.45)**	**2 (2.02)**	**277 (279.80)**	**14 (14.14)**	**52 (52.53)**	**6 (6.06)**	**6 (6.06)**	**1 (1.01)**					**2 (2.02)**	**6**
TEMPORARY	Cattail Marsh (75)		1 (1.33)		1 (1.33)				2 (2.67)	2 (2.67)	2 (2.67)				**4**
	Ephemeral Pond (18)														**0**
	Indian Grave Brook Marsh (50)		7 (14.00)								4 (8.00)				**2**
	Lower Primrose Brook Seep (66)		4 (6.06)						1 (1.52)		1 (1.52)				**3**
	Old Channel Pond (93)		1 (1.08)								5 (5.38)				**2**
	Trail Center Seep (96)		13 (13.54)	3 (3.13)	1 (1.04)				1 (1.04)	1 (1.04)	8 (8.33)	1 (1.04)	1 (1.04)		**5**
	Total (IA)		**26 (6.53)**	**3 (0.75)**	**2 (0.50)**				**4 (1.01)**	**3 (0.75)**	**20 (5.03)**	**1 (0.25)**	**1 (0.25)**		**5**

[1]Ranid species larvae (1) also captured in a minnow trap

Incidental Encounters

Incidental encounters recorded 18 species from 35 locations. Of these, 13 locations were also standardized survey sites. Based on the number of locations recorded, the most widespread (and generally most frequently encountered) species were eastern gartersnake (12 locations), American toad (11 locations), northern green frog (10 locations), and pickerel frog (10 locations) (Table 15). Based on number of adult form individuals represented, the most abundant species were northern green frog (45% of individuals), pickerel frog (23%), eastern red-backed salamander (8%), and eastern gartersnake (5%), and the least abundant species were red-spotted newt, stinkpot, and wood turtle (*Glyptemys insculpta*) (each 0.1% of individuals) (Table 15). Scott Ruhren of Rutgers University (pers. comm.) reported a wood turtle seen in the summer of 1998 at a small stream near Cat Swamp Pond. We included this observation in our data, as an incidental encounter. Gray treefrogs (*Hyla versicolor*) and snapping turtles were the only species recorded solely as incidental encounters.

Table 15. Number of amphibians and reptiles recorded as incidental encounters at 34 locations in Morristown National Historical Park, 13 April to 22 September 2000. Life stage or evidence of presence is: ADL=adult; JUV=juvenile; LAR=larvae; BON=bone; KLL=kill; SHD=snake shed; VOC=anuran vocalization; EGG=egg masses. (#E)=number of times a species was encountered; (#L)=number of larvae counted; (#M)=estimated number of males calling; (#F)=estimated number of adult females. Total Adult is total of all adult form individuals, plus estimated numbers of adults represented by egg masses and vocalizations.

Species	# Sites	# of Individuals by Life Stage/Evidence of Presence												
		Total Adult	% of Total	ADL	JUV	LAR		BON	KLL	SHD	VOC		EGG	
						#E	#L				#E	#M	#E	#F
American Bullfrog	3	38	3.8	33							1	5		
American Toad	11	22	2.2	19	3									
Eastern Box Turtle	4	4	0.4					4						
Eastern Gartersnake	12	45	4.5	11	6				28					
Eastern Red-backed Salamander	7	79	7.9	78	1									
Gray Treefrog	4	15	1.5								5	15		
Northern Green Frog	10	451	45.1	350	49	7	278				12	36	1	16
Northern Dusky Salamander	6	21	2.1	16	5	1	1							
Northern Two-lined Salamander	4	21	2.1	21		1	3							
Northern Watersnake	4	42	4.2	41	1									
Pickerel Frog	10	233	23.3	39	159								1	35
Red-spotted Newt	1	2	0.2	2										
Northern Red Salamander	5	7	0.7	7		3	5							
Northern Ring-necked Snake	2	2	0.2	1	1									
Snapping Turtle	2	3	0.3	2	1									
Stinkpot	1	1	0.1		1									
Wood Frog	2	4	0.4	4										
Wood Turtle	1	2	0.2	2										
Ranid species	2	5	0.5	5		1	1							
unknown species	3	3	0.3							3				
Total		**1000**	**100**	**631**	**227**	**13**	**288**	**4**	**28**	**3**	**18**	**56**	**2**	**51**

Discussion

Community Composition and Important Habitats

Of the 31 species of amphibians and reptiles believed to historically occur at MORR, 21 (68%) were recorded during this inventory (Figure 6). The stinkpot, captured in the Passaic River, was previously unrecorded at MORR and not included on the historical list, though it was likely present. Most of the species recorded are common in the Northeast (Klemens 1993; Conant and Collins 1998) and represent species that are even more widespread. Given that amphibians dominate the herpetofauna of Morristown in terms of species richness (60% of species) and in numbers (92% of individuals), the importance of wetland habitats is evident. With the exception of the eastern red-backed salamander and the slimy salamander, all of the amphibians at Morristown depend on some type of wetland or stream habitat for reproduction. Species richness was greatest at Cat Swamp Pond and the Passaic River with 11 species found at each. Cat Swamp Pond accounted for 42% of all amphibians encountered (Table 2). Because the aquatic resources of MORR are predominately riparian in nature, with limited lentic habitats, most pond breeding amphibian activity is concentrated at Cat Swamp Pond.

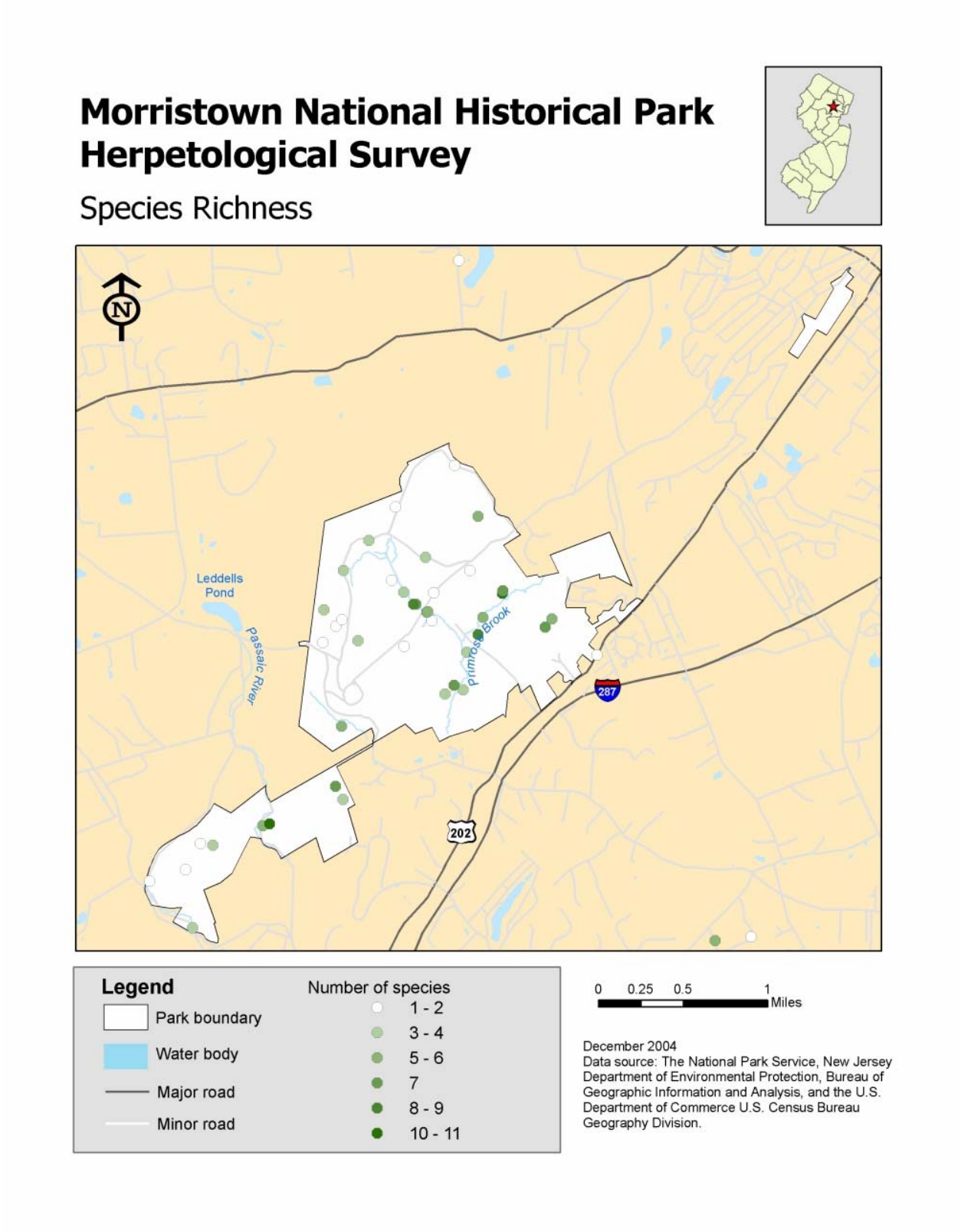

Figure 6. Species distribution maps for amphibians and reptiles recorded in Morristown National Historical Park in 2000.

Uplands had the greatest species richness with 16 species, followed closely by streams with 15 and wetlands with 14 species. Several species were found more frequently in specific habitats. The eastern box turtle, northern ring-necked snake, and eastern milksnake were only found in uplands, primarily fields, and the red-spotted newt and spotted salamander were only found in Cat Swamp Pond (Table 2). Other specialized species were northern two-lined (98%) and northern dusky salamanders (95%) found in stream habitats, and northern green frog (92%), pickerel frog (93%), and American bullfrog (89%) found in wetland habitats. While amphibians and reptiles commonly utilize specific habitats for part of the year, their complex life cycles require the use and occupancy of different habitats for breeding, foraging, and dispersal. Wood turtles inhabit streams most of the year and are primarily terrestrial in the summer (Ernst et al. 1994). Spring peeper, gray treefrog, wood frog, American toad, and spotted salamander, all depart from wetland habitats following the breeding season, foraging and hibernating in the uplands (Conant and Collins 1998; Petranka 1998).

Species at Risk

Most of the 22 species of amphibians and reptiles documented at MORR are common in the Northeast (Klemens 1993; Conant and Collins 1998) and widespread in North America. From a preservation of species at risk perspective, MORR does not support any species that are exceptionally rare, such that it could be considered a critical site for a rare or declining species. The wood turtle is the only species present that is listed by the State of New Jersey (*Threatened*). This is a riparian species, found in wetlands and uplands near stream habitats. Inhabiting clean streams, the wood turtle can also be found away from water in the summer months. Locally, the amount of unpolluted suitable habitat is at risk of diminishing as the area surrounding MORR experiences continued suburban development and urban-suburban populations expand. The preservation of the stream and upland habitats of MORR, as well as the surrounding communities, is important for the local preservation of the wood turtle. In addition, while not listed in NJ, the eastern box turtle is a special concern species in New York State. Box turtles have declined throughout their range due to a number of factors, most relating to aspects of development, habitat fragmentation, and road kill (Dodd 2001). The 15 eastern box turtles recorded suggest that MORR, in concert with adjacent natural areas, may support a locally significant population of this species. To minimize impacts of mowing, avoid mowing in June and July, when turtles nest in fields. Using rotary blades instead of reel mowers, and setting rotary blades a few inches high will also help to reduce chances of mower mortality. For larger fields on park periphery, if staffing permits, mowing half the field each year is preferable to mowing in its entirety, every other year.

Ecological Function

Amphibians and reptiles are important in ecosystem functions, particularly energy flow between trophic levels. In general, they occupy the middle region of the food chain (Zug 1993). Moreover, many species of amphibians and reptiles achieve such densities that they dominate the vertebrate biomass in their respective ecosystems and can influence the structure and composition of plant and invertebrate communities (Burton and Likens 1975; Congdon et al. 1986; Congdon and Gibbons 1989; Gibbons 1988; Pechmann et al. 1989). Thus, even though composed of relatively common species, the herpetofauna of Morristown is important in trophic

dynamics, consuming insects, invertebrates, and small vertebrates, serving as prey for larger vertebrates, and contributing to the overall integrity of the ecosystems in which they occur.

Population Trends

Given the fact that "historical" data for MORR is all post-1980, and that it is generally very limited, trend analysis is difficult. Many records are of incidental observations by staff and visitors, with some qualitative statements regarding abundance (e.g., Morristown NPFauna 1993). We have had to rely on the number and sources of "historical" records, as well as a sense of habitat suitability and animal behavior (i.e., how likely a species is to be encountered by someone not actively seeking them) to infer past abundance at MORR. For many species, much of the "historic record" is based solely on Kent (1980). His observations were not "incidental". Rather, they were based on an informed, active search for animals. But, it was neither systematic nor quantitative.

Quantitative data are limited to those of Mele and Mele (1983), who sampled in and adjacent to five stream sites (Indian Grove Brook, Passaic River, Jersey Brook, and the east and west branches of Primrose Brook). This provides a basis for some trend analysis, though allowances must be made for differences in methodology and mistakes in species identification. First, Mele and Mele (1983) reported 109 Jefferson's salamanders, making it the second most abundant species with a relative abundance of 24.5%. Conversely, they only reported one northern dusky salamander. Jefferson's salamander inhabits deciduous forest, residing in underground burrows for the majority of the year and migrates to vernal ponds in the early spring to breed (Petranka 1998). They are not typically found in stream habitats. An abundance of a generally rare, hard to find terrestrial species in stream habitat, in conjunction with the near absence of what is typically an abundant, easy to find stream species seemed unlikely. Considering that large dusky salamanders superficially resemble Jefferson salamanders, it was likely that dusky salamanders were being mis-identified as Jefferson salamanders. That this is what likely happened was confirmed (pers. comm. between R. Cook and J. Mele, 15 Nov 1999). Thus, in using the data of Mele and Mele (1983), all Jefferson salamanders they report are assumed to actually be northern dusky salamanders.

Secondly, Mele and Mele (1983) surveyed each site five times, with two people searching for ½ hour in stream habitat and ½ hour in the adjacent upland habitat (pers. comm. between R. Cook and J. Mele, 15 Nov 1999). They did not break down their data between stream and adjacent upland. We used stream TCS to sample these same streams. However, because the goal of stream TCS was to sample the stream habitat and not the adjacent uplands, our search did not extend into the uplands. Consequently, compared to the raw data of Mele and Mele (1983), our data are biased towards stream species and against more terrestrial species, such as *Plethodon.* Stream salamander surveys at Delaware Water Gap National Recreation Area showed that *Plethodon* was absent from the stream and splash zones and occurred only in the bank zone, and that for the overwhelming majority of northern dusky and two-lined salamanders the converse was true (Brotherton et al. 2005 in prep). Thus, to provide a more meaningful comparison of our data with that from 1983, we omitted the data on red-backed (190 inds) and slimy salamander (19 inds), and only considered the time spent searching in stream in calculating an index of abundance, catch/search hour (Table 16).

Table 16. Comparison of Index of Abundance and Relative Abundance at five streams sampled in 1983 (Mele and Mele 1983) and in 2000. To enable a more valid comparison of stream sampling, data of Mele and Mele (1983) on slimy and red-backed salamander are not included in calculations of IA nor RA.

	Mele and Mele (1983)				2000			
Species	**survey site[1]**	**# of individuals**	**IA[2]**	**RA**	**survey site[1]**	**# of individuals**	**IA[3]**	**RA**
Northern Dusky Salamander	1 to 5	110	4.4	47.0%	2 to 5	185	2.53	38.3%
Northern Two-lined Salamander	1 to 5	91	3.64	38.9%	2 to 5	244	3.34	50.5%
Slimy Salamander	2 to 5	19			5	1	0.01	0.2%
Northern Greenfrog	1,2	26	1.04	11.1%	1 to 5	24	0.33	5.0%
Northern Watersnake	4	1	0.04	0.4%	2	5	0.07	1.0%
Eastern Gartersnake	4	1	0.04	0.4%	3	1	0.01	0.2%
Eastern Red-backed Salamander	1 to 5	190						
Red Salamander					2,5	5	0.07	1.0%
Red-spotted Newt	4	2	0.08	0.9%				
American Bullfrog					2	1	0.01	0.2%
Pickerel Frog					2,4,5	16	0.22	3.3%
Wood Frog					2	1	0.01	0.2%
Northern Leopard Frog	1	1	0.04	0.4%				
Snapping Turtle	1	1	0.04	0.4%				
Eastern Box Turtle	1	1	0.02	0.2%				

[1]Survey site: (1) Indian Grave Brook, (2) Passaic River, (3) Jersey Brook, (4) Primrose Brook East, (5) Primrose Brook West
[2]Based on 25 search hours, representing time spent searching in stream
[3]Based on 73 search hours

MORR stream herpetofauna continues to be dominated by northern dusky and two-lined salamanders. Collectively, they accounted for 88% of all in-stream captures in 1983 and 89% in 2000 (Table 16). However, in 1983 the dusky salamander was most abundant whereas in 2000, the two-lined salamander was. Numbers of dusky salamander relative to two-lined salamanders changed significantly from 1983 to 2000 (χ^2= 7.4, df=1, p=0.007) and abundance of dusky salamanders (i.e., numbers captured relative to search time) also declined significantly, from 4.4 to 2.53 inds/hour (χ^2= 4.53, df=1, p=0.033). In contrast, abundance of two-lined salamanders, from 3.64 to 3.34 inds/hour, did not change significantly (χ^2= 0.11, df=1, p=0.745). While the work in 2000 was not designed specifically to test these questions, and differences between 1983 and 2000 may be sampling artifacts, they may also indicate the beginnings of a decline in dusky salamanders. Northern dusky salamanders are less tolerant of urbanization than two-lined salamanders (Klemens 1993) and have even apparently disappeared from large natural areas such as Acadia NP (Brotherton et al. 2004). Thus, while dusky salamanders continue to be common at MORR, their status is cause for concern that warrants follow-up monitoring.

In addition to northern dusky and two-lined salamanders, seven other species were recorded in-stream in 1983, eight in 2000, with three species overlapping. However, numbers of individuals were relatively small and, except for the red salamander, they are essentially species that utilize streams as travel corridors. These data alone are not useful for trends analysis, though they may still be of use in conjunction with other data at a park-wide scale.

In the species accounts below, we have attempted to assess each species' status and population trends. As discussed above, this is a somewhat subjective process, comparing our data with the limited historical data available. Our data were collected deliberately in a single field season, whereas park records and reports span a period of ca. 20 years, and many were the result of chance encounters. Of the 31 species accepted as historically present, 18 appear to be stable, i.e., do not appear to be any more or less common or rare than "historically" (Table 17). Thirteen appear to show some evidence of decline, though the extent of apparent decline varies. Species such as the northern dusky salamander, slimy, and spotted salamander are species formerly abundant to common that are still present, but in lesser numbers. The spring peeper, formerly common at one site, was not recorded at MORR nor were any other of the remaining nine declining species. It is doubtful, however, that these nine had been very numerous at MORR during the "historic" period in the first place. The last two other species, marbled and Jefferson-complex salamanders, were also not recorded, but the "historic" record is too uncertain, and we considered these to be of unknown status.

Table 17. "Historic" status and apparent trends in amphibians and reptiles at MORR. *not recorded in 2000.

	Stable	→	Declining
Abundant	Northern Greenfrog Northern Two-lined Salamander Eastern Red-backed Salamander	Northern Dusky Salamander	
Common	Eastern Box Turtle American Bullfrog American Toad Pickerel Frog Red-spotted Newt Eastern Gartersnake Northern Watersnake		Spring Peeper* Spotted Salamander
Uncommon	Wood Frog Red Salamander Painted Turtle Snapping Turtle Northern Ring-necked Snake		Gray Treeefrog Four-toed Salamander* Slimy Salamander
Rare	Wood Turtle Eastern Milksnake Stinkpot		Eastern Cricket Frog* Spring Salamander* Long-tailed Salamander* Northern Black Racer* Northern Brownsnake*
Unknown		Jefferson Salamander* Marbled Salamander*	

Stressors

While roughly half of MORR's amphibian and reptile species appear to be maintaining themselves, the herpetofauna of Morristown is in decline. While determining the cause(s) of these declines is beyond the scope of this inventory, it is likely the result of a combination of the same factors believed to be responsible for amphibian declines worldwide. These include global stressors, which tend to affect large geographic areas and are often far removed from the ultimate cause or source, and regional/local stressors, which work at a more localized level. Global stressors include ultraviolet-B radiation and atmospherically transported pollutants such as mercury and acid rain. Stressors such as other heavy metals, chemicals found in fertilizers, herbicides, and pesticides, habitat degradation, disease, road mortality, and introduced species (Dunson et al. 1992; Blaustein 1994; Blaustein et al. 1994; Pechman and Wilbur 1994; Hunter et al. 1999; Daszak et al. 2000; Knapp and Matthews 2000) may also be widespread in their scope, but tend to be more variable across the landscape in their extent. Thus their impacts may be at either a regional or local level.

Local stressors seem to play a prominent role in the decline of species in the park. Amphibian egg masses and larvae are preyed upon in bodies of water with fish present (Pough 1998). The introduction of fish into Cat Swamp Pond within the last twenty years (Masson pers. comm.) has likely contributed to the decline of some amphibian species at this site, particularly spotted salamanders. Also contributing to the decline of temporary pond breeding amphibians at MORR are changes at Cattail Marsh due to plant succession. Whether this is the result of any human activity is unknown.

High levels of pollutants could also negatively impact the amphibians and reptiles in the park. Changes in stream water quality appear to have occurred. In 1983, surface water quality at MORR was "outstanding" (Mele and Mele 1983), though possible fecal coliform contamination in Primrose Brook was noted. Subsequent investigation in 1986 and 1989 revealed elevated levels of fecal coliform (Trama and Galloway 1988). In 1995, the headwaters to Primrose Brook West were closed due to high levels of fecal contamination and the septic system located upslope of the brook replaced. Berger (1998) investigated further to determine the potential source(s) and extent of the contamination, and revealed that the Primrose Brook (the main, east and west tributaries), Jersey Brook, Indian Grave Brook, and the Passaic River were contaminated with fecal coliform and other bacteria. Collectively, this body of work shows high levels of fecal coliforms in the surface and shallow ground waters at MORR. Contamination within Jockey Hollow (Primrose and Jersey Brooks) was high in the spring, summer, and early fall months, whereas high bacteria levels (contamination) outside of Jockey Hollow (Passaic River and Indian Grave Brook) was more variable, occurring throughout the year. This implies a difference in bacteria source for these two areas. Jockey Hollow experiences increased wildlife activity and domestic animal presence in the park during warmer months, contributing to high bacterial contamination during this time of the year. The drainage areas of the Passaic and Indian Grave Brook include residential areas with greater potential for leaking septic systems throughout the year (Berger 1998).

Mele and Mele (1983) also noted a concern over aluminum levels (range 0.091 to 0.360 mg/L) and potential for future impacts. Acid rain (low pH) can increase the solubility of aluminum to levels toxic to amphibians (Clark and Hall 1985). While aluminum toxicity is greatest in highly

acidic streams, and MORR stream pH in 1983 was only slightly acidic, *in-vitro* toxicity tests in neutral waters (Birge et al. 2000) found lethal effects to some amphibian eggs and larvae at levels below the concentrations found at MORR in 1983. Thus it is possible that aluminum may be affecting amphibians at MORR.

Changes in terrestrial habitats due to deer overabundance and invasive alien worms may also be contributing to herpetofaunal decline. Since 1980, the deer population at MORR has increased (Masson pers. comm.). Increased deer browsing has increased the browse line, decreased the woodland understory and, through increased evaporation, led to decreased moisture in the soil and leaf litter. However, since 1996-1997 the deer population data has shown a 30-35% decline. Having a similar effect are non-native worms. Non-native worm species are rapidly decreasing the amount of leaf litter, accelerating dehydration in the soil (M. Carreiro pers. comm.). The combined effect of these two stressors is a reduction in the amount of leaf litter and soil moisture, leading to increased desiccation for amphibians inhabiting these areas, as well as a reduction in escape cover. Thus, an increase in worm activity one year might be associated with a decline in amphibian and reptile populations in subsequent years (M. Carreiro pers. comm.). In addition, invasive plant species can contribute to the decline of species. Much of the park landscape has been manipulated over the years, allowing for the invasion of non-native plants. Left unchecked, non-natives can spread and overwhelm native vegetation and permanently alter the nature of wetland and upland habitats. Altogether, these stressors, working directly or indirectly, can reduce or eliminate the park's most sensitive species (Orser 1972; Pough 1976; Pough and Wilson 1977; Gore 1983; Clark 1986; Karns 1992; Sadinski and Dunson 1992).

Road kill is another stressor, particularly given the high traffic volume suburban landscape in which MORR is located. Many roads border the park and several wind throughout the property. In the Northeast, several species of salamanders migrate to breeding ponds in the spring (Petranka 1998), frequently crossing roads in large numbers on rainy nights. Turtles travel over land in search of nesting sites in June and July, crossing roads they encounter along the way. Thus vehicle traffic can cause significant amphibian and reptile mortality in populations whose habitat is bisected by roads (Fahrig et al. 1995; Gibbs and Shriver 2002). In 2000, eight of the 22 species detected were recorded on roads, including 28 DOR (dead on road) eastern gartersnakes. When recognized, steps to reduce road kill should be taken where possible. Sections of road where numbers of migrating amphibians and reptiles are known to cross should be monitored to assess road-kill. Temporary closure of roads near breeding sites during peak breeding and nesting seasons (especially on rainy nights) are recommended to minimize road mortality. Road sections where amphibian and reptile mortality occur should be evaluated for installation of speed bumps and warning signs, elevating above grade, or installation of wildlife friendly road tunnels and leaders to provide safe travel routes for migrating animals in heavy traffic areas (Jackson 1996; U.S DOT-FHA Critter Crossings), particularly when these can be incorporated into road rehabilitation and reconstruction projects.

Like many NPS sites in the Northeast, MORR now stands as an island of wildlife habitat in an increasingly fragmented, human-altered landscape. Roads and suburban development tend to isolate it, with few safe avenues for immigration or emigrations. The movement of animals off site increasingly results in the loss of individuals from the MORR populations, with chances of successful colonization/re-colonization low. Over time, this can create local extinction of species (Primack 1993). Such seems to be the case at MORR.

Summation

While this inventory provides information on the status of most species known to occur at MORR, it leaves many questions unanswered. Of the 31 species believed to have occurred historically at MORR, 21 (68%) were documented in 2000. Of these, 18 appear to be stable in terms of their population trends and the remaining 13 species have declined. Some of this decline is likely due to inherent habitat limitations at MORR, i.e., it contains few of the pond habitats required to support many of the local amphibian species. As these habitats change to densely vegetated marsh wetlands and/or invasive fish and plant species become established, amphibians can no longer maintain their populations. Also, much of the decline seems to involve species that, due to limitations of habitat, were probably never very common to begin with. Their apparent disappearance from MORR is likely part of a larger, regional decline, in concert with the increasing isolation of MORR. There are likely fewer individuals moving about the landscape in the first place, with less likelihood that they will be able to successfully make it to MORR in the face of dispersal barriers such as roads.

The apparent decline and extirpation of a number of species at MORR highlights the importance of a program of standardized monitoring. While a detailed monitoring plan is beyond the scope of this inventory, the decline of several amphibian species suggests that amphibian monitoring, particularly a program of anuran calling surveys, stream salamander surveys, and surveys of breeding ponds with minnow traps and egg mass counts should be a high priority. Such long term monitoring is important to better separate natural fluctuations in populations over time from anthropogenic declines (Pechmann et al. 1991; Pechmann and Wilbur 1994; Stebbins and Cohen 1995). In addition, a more in-depth analysis of changes in stream and terrestrial habitat quality might help to better identify the causes of changes in the herpetofauna. Though it is based on less than ideal baseline information, the picture that emerges is one in which a site with somewhat limited habitat diversity to begin with has suffered a decline in herpetofauna due to site-specific habitat changes, exacerbated by landscape changes occurring at a broader regional level.

Species Accounts

Salamanders

Eastern Red-backed Salamander (*Plethodon cinereus*)

This species is common in the forests of the northeastern United States and southeastern Canada, with the greatest densities in well-drained, mature forests (Petranka 1998; Pfingsten and Downs, 1989). It occurs as a number of different color morphs, with the red striped and all gray unstriped the two most common and widespread in New England (Klemens 1993). Of 311 individuals for which color morph was recorded in this inventory, there were 162 red-striped and 149 unstriped.

The historic record indicates the red-backed salamander was an abundant and widespread species (Kent 1980; Mele 1981; NPS Natural History Observations 1991, 1993; Morristown NPFauna 1993). Mele and Mele (1983) sampled uplands adjacent to five stream sites, and found this species to be widespread and the most abundant of the herpetofauna (IA=7.6). In 2000, red-backed salamander was again the most abundant and widespread salamander recorded. A total of 391 individuals (RA=16.16%) were recorded at 14 localities (FO=31.1%), primarily in deciduous forest (78.5 % of all inds) but also along streams and in wetlands (Tables 2 and 3, Appendix 8 and 9). In deciduous forest, the IA was 4.14 inds/hr (Table 9). While this capture rate is less than that in 1983, this could be due to differences in sampling locations or many other factors, and it is difficult to interpret as a real change in abundance. Thus, it appears that red-backed salamanders continue to be an abundant and widespread species at MORR.

Northern Two-lined Salamander (*Eurycea bislineata*)

The northern two-lined salamander is likely the most widespread and abundant stream salamander in New England, and is the most urban tolerant (Klemens 1993), even occurring in a small length of remnant stream at the heavily urbanized Saugus Iron Works NHS in Saugus MA (R. Cook, pers. obs.). This stream salamander is typically more aquatic in nature than the northern dusky salamander, often found in the stream and splash zones of cool, swift moving streams. Females deposit eggs singly on the underside of flat rocks in the stream (Petranka 1998; Pfingsten & Downs 1989). Kent (1980), NPS Natural History Observations (1983-1999) and Morristown NPFauna (1993) reported general observations of northern two-lined salamanders in the park. Mele and Mele (1983) found the northern two-lined salamander at all five of their sampling locations and it was the second most abundant stream salamander (IA=3.64). We found this species at four of the same five sampling locations, and it was the most abundant species found in streams (IA=3.34). A total of 307 adults were recorded from 11 localities in streams (8 streams), wetlands (1 marsh), and uplands (2 woodlands) (Tables 2 and 3, Appendix 8 and 9). The historic account by Mele and Mele (1983) suggests the northern two-lined salamander was relatively common. Based on this inventory, it still appears to be widespread and abundant in stream habitats, possibly replacing dusky salamanders as the most abundant species in stream habitats.

Northern Dusky Salamander (*Desmognathus fuscus*)

The northern dusky salamander is widespread through Eastern North America and has been found throughout most of New Jersey, except for the southern counties of the state (Schwartz and Golden 2002). This is a streamside species typically found under rocks and logs in the water and along the edge of cool woodland streams, springs, and seeps. Females typically deposit egg clusters in a scooped out depression under rocks or logs along the edge of a stream, and will brood the eggs for a period of time before they hatch (Hunter et al. 1994; Petranka 1998; Pfingsten and Downs 1989). Kent (1980) reported this species and data collected at five stream sites in 1983 show it was widespread, and the most abundant species of stream salamander, with an index of abundance of 4.4. (Mele and Mele 1983). We found northern dusky salamanders at four out of these same five locations, and it was the second most abundant species (IA=2.53). In 2000, a total of 254 northern dusky salamanders were recorded from 13 localities in streams (8 streams), wetlands (4 wetlands), and uplands (1 woodland) (Tables 2 and 3, Appendix 8 and 9). While the northern dusky salamander remains widespread and abundant, its relative and absolute abundance declined significantly from 1983 to 2000 (Table 16). This may be a sampling artifact or short term change. However, the dusky salamander is known to decline as urbanization increases (Klemens 1993) and it has also declined from relatively pristine areas such as Acadia NP (Brotherton et al. 2004). Considering the urbanization that has occurred adjacent to MORR in recent decades, it is also possible that this is the start of a decline. A rigorous program of stream salamander monitoring is needed to better track these trends.

Red-spotted Newt (*Notophthalmus viridescens viridescens*)

The life history of the eastern newt differs from other salamanders, in that it generally metamorphoses twice. Adults primarily occur in still bodies of water such as ponds and lakes and are aquatic. Following a typical aquatic embryonic and larval stage, juveniles transform into a terrestrial juvenile stage known as red efts. The eft, bright orange with red spots, may be found under logs and brush or seen moving in woodlands and grassy areas, particularly during rainy conditions (Petranka 1998; Pfingsten and Downs 1989). The efts may spend 2-7 years on land before returning to water and transforming into an aquatic adult, taking on the adult's green coloration and keeled tail (Healy 1974). While red efts may be handled safely by humans, they have toxic skins that deter potential predators (Hurlbert 1970). The newt is considered to be a keystone predator in temporary pond communities where they control insect populations and anuran species composition (Kurzava and Morin 1994). Clear-cut timbering may significantly effect newt populations (Petranka et al. 1993) and repopulation may take 30-60 years (Pough et al. 1987).

The red-spotted newt is found in every county in New Jersey (Schwartz and Golden 2002). Kent (1980) reported this species in Cattail Marsh. None were found there in 2000. Cattail Marsh has changed from an open water wetland in 1980 to a densely vegetated marsh, unsuitable for red-spotted newts. Mele and Mele (1983) found 2 individuals in the east branch of Primrose Brook. We found 89 adults all at Cat Swamp Pond. It was the sixth most abundant species identified during the entire survey (RA=3.68%) but among the least widespread in the park (FO=2.2%) (Tables 2 and 3, Appendix 8 and 9). Previous studies indicate this species is not very widespread in the park. As a species primarily dependent on permanent ponds for successful reproduction

and as adult habitat, red-spotted newts are largely concentrated at Cat Swamp Pond, where it remains a common species.

Northern Red Salamander (*Pseudotriton ruber ruber*)

The northern red salamander is a brilliant red to reddish orange stream salamander and has numerous black spots. Widespread in New Jersey, the stout adults are found under debris or in burrows near streams, beneath logs, under flat rocks and moss, and larvae are found in streams under rocks and cover in the stream (Schwartz and Golden 2002, Petranka 1998; Pfingsten & Downs 1989).

Kent (1980) and NPS Natural History Observations (1991, 1993) report general observations of northern red salamanders from the Aqueduct Trail and Trail Center. In 2000, the northern red salamander was the tenth most abundant species identified (RA=1.03%) (Tables 2 and 3, Appendix 8 and 9). It was also widespread, recorded from 13 out of 45 localities (FO=28.9%), including five streams, six wetlands, and two woodlands (Tables 2 and 3, Appendix 8 and 9). While historic data are limited, they suggest that red salamanders were uncommon though likely widespread. Results from this study indicate the northern red salamander remains so, primarily in stream and wetland habitats.

Northern Slimy Salamander (*Plethodon glutinosus*)

The northern slimy salamander is a terrestrial salamander and gets its name from the sticky, glue-like substance it exudes from the tail when it is disturbed. They are found under rocks, logs, and other debris in eastern deciduous forests, bottomland hardwoods, swamp forests, and wet pinewoods (Petranka 1998; Pfingsten & Downs 1989). They are distributed throughout the northern region of New Jersey and northwestern Monmouth County in the southern region (Schwartz and Golden 2002).

Kent (1980), NPS Natural History Observation (1991), and Morristown NHP NPFauna (1993) reported general observations of this species. Kent (pers. comm. to R. Cook, 2000) stated they were as common as red-backed salamanders, though data collected in 1983 does not bear this out (Mele and Mele 1983). Sampling in uplands adjacent to five stream sites recorded a total of 19 individuals at four of five sites, with an IA of 0.76 inds/hour. In contrast, the same sampling in 1983 produced 190 red-backed salamanders (Mele and Mele 1983). At Scherman-Hoffman sanctuary, slimy salamanders are considered uncommon and red-backed salamanders common (NJ Audubon 2003). In 2000, we found eight individuals from four sites, including West Primrose Brook, a site where Mele and Mele (1983) also recorded this species (Tables 2, 3, and 16, Appendix 8). In time constrained search of uplands, we recorded three individuals in 74.2 search hours (IA=0.04). While some of this difference between 1983 and 2000 may be due to differences in sample sites and other factors, an order of magnitude decrease in Index of Abundance suggests that slimy salamanders may be declining.

Spotted Salamander (*Ambystoma maculatum*)

The spotted salamander is essentially a terrestrial species that depends on ponds for embryonic and larval development. Adults are most easily detected in early spring, when they migrate on rainy nights from underground burrows to breeding ponds. There mating occurs and females attach gelatinous egg masses to twigs and vegetation in the pond (Petranka 1998). Morristown NPFauna (1993) reported general observations of this species in the park and Kent (pers comm. to R. Cook and L. Morales) recalled observing hundreds of adult and larval spotted salamanders between 1978-1980 in Cattail Marsh and Cat Swamp Pond. In 2000, the spotted salamander was among the least abundant and least widespread species (RA=0.24%, FO=2.2%) found at MORR. Six adults were captured in minnow traps on 17 and 21 March, and six larvae on 17 and 18 August, and 13 September at Cat Swamp Pond (Table 14). None were found in Cattail Marsh.

This apparent decline in abundance is likely the result of changes to the few wetland habitats in the park capable of supporting breeding. Successional changes at Cattail Marsh since 1980 have created less open pond habitat, and a shorter hydroperiod (Kent pers. comm.). At Cat Swamp Pond, fish have been introduced (Masson pers. comm.) and this pond now supports an abundant population of golden shiner (*Notemigous crysoleucas*). Mather et al. (2003) captured 930 individuals overnight using five fyke nets and 15 minnow traps. Predation on eggs and larvae by the golden shiner has likely affected the survivorship of spotted salamanders in the pond and caused their decline to the point where they are uncommon.

Jefferson Salamander (*Ambystoma jeffersonianum*)

Jefferson salamanders are found in the northern region of New Jersey (Schwartz and Golden 2002). They often migrate to ice covered ponds in New York (Bishop 1941), sometimes as early as January in Pennsylvania (D. Brotherton pers. obs.). Females deposit gelatinous egg masses on twigs and leaves in the pond, then leave the pond, dispersing into adjacent woodlands (Petranka 1998; Pfingsten and Downs 1989).

Kent (1980) reported Jefferson salamanders in the Cattail Marsh area and NPS Natural History Observations (1983-1999) reported general observations in the park. However, *A. jeffersonianum* comprises a complex of diploid and triploid hybrid species that can be difficult, if not impossible to identify in the field. In New Jersey, *A. jeffersonianum* and its triploid hybrid *A. platineum* occur northwest of MORR whereas the blue-spotted salamander *A. laterale* and its tripoloid hybrid *A. tremblayi* occur within the Passaic River basin, including the Great Swamp, ca. 5-10 km from MORR (Nyman et al. 1988). Considering that *A. laterale* and *A. tremblayi* were found to breed in flood plain pools, ponds and swamps, and *A. jeffersonianum and A. platineum* were not found in flood plain habitats (Nyman et al. 1988), it seems more likely that if members of this complex are present at MORR, it would be *A. laterale* and *A. tremblayi.*

No members of the *A. jeffersonianum* complex were found in 2000. While it is possible that the same factors responsible for the decline of spotted salamanders has affected this species as well, the historic record is so meager that it does not provide much of a basis for comparison. Because we are uncertain of how common or rare it previously was, and can only say that it is either rare or absent at present, their status and trend is undetermined. Additional, intensive surveys at Cat

Swamp Pond, Cattail Marsh, Ephemeral Pond, Old Channel Pond and other potential breeding sites in March are recommended to better determine their status at MORR.

Marbled Salamander (*Ambystoma opacum*)

In New Jersey, marbled salamanders range throughout the entire state (Schwartz and Golden 2002). They are terrestrial, migrating to temporary or semi-permanent ponds in September to breed (Anderson and Morales 1973; D. Brotherton pers. obs.). Females dig nests and deposit eggs in the dry pond basin or along the margins of reduced pond, and then exit the pond and return to the surrounding woodlands. Ground water, precipitation, and snow melt fill these ponds, initiating hatching followed by larval development in the spring (Petranka 1998; Pfingsten and Downs 1989). Kent (1980) reported a marbled salamander near Cattail Marsh. None were recorded in 2000. Considering the limited historic information on the occurrence of marbled salamanders at MORR, and the relative difficulty in finding this species, it is difficult to say much regarding either the status or trends of his species.

Their status in the park is undetermined. Further surveys at Cattail Swamp, Cat Swamp Pond, Ephemeral Pond, Old Channel Pond in September and the spring are recommended.

Four-toed Salamander (*Hemidactylium scutatum*)

These salamanders are found throughout New Jersey in wet areas with sphagnum moss in mature forests, marsh and bog habitats (Schwartz and Golden 2002). Females deposit clusters of eggs, oftentimes in communal nests, in "sphagnum cliffs". These are areas of sphagnum moss/sedge clumps rising up from the water of small ponds, temporary ponds, and marshes that are used by nesting salamanders. The nests are created in these clumps so as the larvae hatch, they will be able to descend the moist moss and enter the water where they will develop and eventually metamorphose and exit the pond or marsh (Petranka 1998; Pfingsten and Downs 1989).

Kent (1980, pers. comm. with R.Cook, pers. comm. with L. Morales 12 Sept 2000) recalls observing four-toed salamanders under clumps of sphagnum moss in and around Cattail Marsh, an area he described as containing water up to a foot in depth. He considered them common at this site though overall they were likely uncommon. None were recorded in 2000. In March 2000, Cattail Marsh had little to no water and was mostly muddy, with no evidence of sphagnum moss. Succession changes since 1980 have reduced the amount of open water, water depth, and hydroperiod at Cattail Marsh (Kent pers. comm. to R. Cook and L. Morales, 2000). While it is not possible to conclude positively that four-toed salamanders have been extirpated at MORR, these habitat changes appear to have caused their decline.

Long-tailed Salamander (*Eurycea longicauda longicauda*)

Listed as *Threatened* by the New Jersey Department of Environmental Protection, the long-tailed salamander is found in the northern region of New Jersey, inhabiting calcareous, spring-fed seeps, springs, stream-sides, floodplains, caves, and mines within upland forests including mature, closed canopy mixed deciduous, mixed hardwood, or hemlock/mixed deciduous forests (Conant and Collins 1998; Schwartz and Golden 2002; NJDEP species description).

Kent (1980) reported the long-tailed salamander in a stream section near the Grand Parade area. There is no information to suggest it was common. The occurrence of this species' in New Jersey is associated with calcareous landscapes, which lie well to the west of MORR (NJDEP 1999). MORR is underlain by gneiss (NPS 1998). None were recorded in 2000, nor in 50 hours of search in streams and adjacent uplands in 1983 (Mele and Mele 1983). Based on these results, and the lack of suitable habitat, we suspect that this poorly documented, habitat-specific species, no longer occurs in the park. It is not likely that long-tailed salamanders were ever common at MORR.

Spring Salamander (*Gyrinophilus porphyriticus porphyriticus*)

In New Jersey, spring salamander is found in the northern region of the state in cool mountain streams and seeps (Schwartz and Golden 2002). Kent (1980, pers. comm. to R. Cook, 2000) found one in West Primrose brook, near the Grand Parade ground. None were recorded in 2000, nor in 50 hours of search in streams and adjacent uplands in 1983 (Mele and Mele 1983). Based on these results, we suspect that this poorly documented, species, no longer occurs in the park. MORR lies at the edge of its range and it was probably rare in the "historic" period.

Frogs

Northern Green Frog (*Rana clamitans melanota*)

The northern green frog is a common and widespread species in the Northeast and mid-Atlantic regions (Conant and Collins 1998), is found in every county in New Jersey (Schwartz and Golden 2002). It utilizes a broad range of freshwater habitats, especially permanent bodies of water, which it requires for successful reproduction. Dorsolateral ridges extending down the back help distinguish the northern green frog from the bullfrog; in bullfrogs, these ridges are absent.

The northern green frog was the most common species identified in the park with 625 adults (RA=25.84%) recorded from 16 sites (FO=35.6%) in all habitat types. The majority (71%) of individuals were recorded from MORR's only permanent pond, Cat Swamp Pond (Tables 2 and 3, Appendix 8 and 9). The American toad was the only other anuran as widespread. While adults breed in and generally inhabit permanent and semi-permanent ponds, dispersing juvenile northern green frogs commonly use streams as travel corridors. We found 6.4% of northern green frogs in stream habitat. The northern green frog was the only species recorded during call count surveys, heard only at Cat Swamp Pond (Table 7). Highlighting the importance of Cat Swamp Pond to this species, it produced all but three of 1,268 green frog larvae recorded in 2000.

Historically, northern green frogs were abundant and widespread at MORR (Kent 1980; Morristown NPFauna 1993; Mele and Mele 1983), with Cat Swamp Pond the only documented breeding pond in the park (Mele 1981). Our results indicate this is still the case.

Pickerel Frog (*Rana palustris*)

The pickerel frog is common and widespread in the Northeast and mid-Atlantic regions (Conant and Collins 1998), and is found throughout New Jersey except for the core Pinelands (Schwartz and Golden 2002). This species is distinguished from the southern leopard frog by having square rather than round spots forming two rows down the back, and the inner surfaces of the hind legs are orange or yellow.

The pickerel frog was the second most common species at MORR, with 432 adults (RA=17.86%) recorded from 15 sites (FO=33.3%) in all habitat types. Similar to the northern green frog, the majority of observations were from permanent ponds (77%) (Tables 2 and 3, Appendix 8 and 9). The pickerel frog was reported by Kent (1980) from Cat Swamp Pond and Cattail Marsh and these two sites accounted for 88% of all adult pickerel frogs recorded in 2000, with 333 and 45 individuals, respectively. In addition, 30 egg masses were recorded, all at Cat Swamp Pond. Pickerel frog is listed as common at Scherman-Hoffman sanctuary (NJ Audubon 2003). As best as can be determined, it was and continues to be a common and widely occurring species at MORR, though highly dependent on Cat Swamp Pond for breeding.

American Bullfrog (*Rana catesbeiana*)

The American bullfrog, New Jersey's largest frog, is a widespread and common species throughout much of the Northeast, though it is absent from the acidic waters of the Pinelands (Behler and King 1979, Klemens 1993, Schwartz and Golden 2002). Bullfrogs require two or more years for their tadpoles to metamorphose, hence it occurs primarily in open bodies of water such as lakes and permanent ponds (Conant and Collins 1998). Their primary habitat requirement is a permanent water body with abundant emergent and shoreline vegetation (Hunter et al. 1999). This species is an aggressive predator that includes other frogs, young turtles, small snakes, and a potpourri of invertebrates in its diet. It is adept at colonizing new habitats, especially those constructed or modified by humans (Lacki et al.1992) and is relatively urban tolerant (Klemens 1993). While native to Morristown, when introduced to areas where they are not native, bullfrogs can displace native species (Stumpel 1992; Adams 1999) and their tadpoles may dramatically alter aquatic community structure (Kupferberg 1994).

Past observations report the American bullfrog from Cattail Marsh and Cat Swamp Pond (Kent 1980; Mele 1981; Rosato 1998; Anderson pers. comm.) and consider it to be common (Morristown NPFauna 1993). In 2000, 53 American bullfrogs were recorded from four sites (RA=2.19%, FO=8.9%). Forty five (85%) of these were from Cat Swamp Pond, a permanent water body (Table 2 and 3, Appendix 8 and 9). None were found at Cattail Marsh, a wetland that has changed considerably over time, from an open water body to a marsh dense with herbaceous vegetation and less open water (Kent, pers. comm. to L. Williamson). While it occurs primarily at Cat Swamp Pond, the only suitable open, permanent pond habitat in the park, bullfrogs still remain common at MORR.

American Toad (*Bufo americanus*)

The American toad is widely distributed and common in the northern region of New Jersey, except for Monmouth County, and is easily confused with the Fowler's Toad (Schwartz and Golden 2002). The American Toad is distinguished from the Fowler's Toad by the number of warts in the blotches on its back. American Toads have no more than two warts per blotch, whereas Fowler's Toad has three to seven. Also, the parotoid gland does not contact the ridge behind the eyes on the American Toad (Schwartz and Golden 2002). Similar to spring peeper and wood frogs, it is primarily a terrestrial species, utilizing a wide range of temporary and permanent wetlands for reproduction. This terrestrial species can be found under cover such as flat stones, boards, and logs, and is easily distinguished by its prolonged, high pitched, trilled call heard in the spring and summer.

The American toad was less common than other species (26 adults, RA=1.07%) and was tied with northern green frog as the most widespread anuran recorded in 2000 (FO=35.6%). It occurred in all habitat types, but, consistent with it being a terrestrial species, the majority of individuals (85%) were found in uplands (Tables 2 and 3, Appendix 8 and 9). The historic record (Kent 1980; NPS Natural History Observations 1983-1999; Morristown NPFauna 1993) describes it is as a common resident and it is also common at Scherman-Hoffman sanctuary (NJ Audubon 2003). Although not as common as some species at MORR, American toad nonetheless remains common and widespread..

Gray Treefrog (*Hyla versicolor*)

Both the gray treefrog and Cope's gray treefrog (*Hyla chrysoscelis*) are found in New Jersey. The former is found throughout the entire state except for the core Pinelands, and the latter, listed as *Endangered* by the New Jersey Division of Fish and Wildlife, is found only in Cape May and southern Cumberland, Ocean, and Atlantic Counties in the Southern Region (Schwartz and Golden 2002). Both species are identical in appearance and can only be distinguished by call or chromosome count. *H. versicolor* has a slow trill while that of *H. chrysoscelis* is quicker, shorter, and higher-pitched (Schwartz and Golden 2002). Genetically, *H. chrysoscelis* is diploid, whereas *H. versicolor* is tetraploid (White and White 2002).). This species has large toe pads and lives high in trees, descending at night to call and breed (Behler and King 1979).

Based on calling males, we identified *H. versicolor* during this survey. These were all incidental encounters on June 1, heard calling with a maximum call index of three (est. # of ind=15). Adults were heard calling adjacent to the park along Route 202, as well as 6.4 km (4 miles) away from MORR in Great Swamp National Wildlife Refuge along Long Hills Road and Whitebridge Road (Tables 2, 3, Appendix 9). No specific wetlands were identified. Kent (1980, pers. comm. 2000) recorded gray treefrog from Cattail Marsh, an open water pond at the time. This wetland has become dominated by cattail with little open water habitat remaining. In 2000, we did not record this species at Cattail Marsh or anywhere else at MORR. Several years ago, the Scherman-Hoffman Sanctuary supported a population of gray treefrog in an artificial pond (child's pool) behind the park office. This small pool was removed and the number of gray treefrogs has declined (NJ Audubon 2003). The evidence suggests that, with limited pond habitats here, gray treefrog may never have been very common. Recent data suggest that gray

treefrogs have declined at MORR, possibly due to changes at Cattail Marsh and Cat Swamp Pond. However, they appear to still be common nearby, presumably where quality breeding ponds still exist.

Wood Frog (*Rana sylvatica*)

The wood frog is widespread in New Jersey but uncommon in the core Pinelands. It is a terrestrial species, occupying moist woodlands except during the breeding season when they breed in fishless vernal pools (Schwartz and Golden 2002). Breeding early in the spring (late-February-March), the wood frog is an explosive breeder. Often a large percentage of a population migrate to ponds in a short window of time, laying eggs together in large floating masses. The wood frog will often travel away from water in the summer and will hibernate in leaf litter during the winter (Behler and King 1979).

Based on a few records over the years (Kent 1980; Morristown NHP Natural History Observations 1983-1999), wood frog appears to have been an uncommon species at MORR. In 2000, we found it to be among the least common and least widespread species (RA=0.21%, FO=6.7%). Only five adults were recorded, one in the Passaic River and the other four in fields (Tables 2 and 3, Appendix 8 and 9). MORR lacks the isolated woodland vernal ponds typically used by wood frogs for breeding and has probably never supported a large population. While they are uncommon, their status does not appear to have changed.

Spring Peeper (*Pseudacris crucifer*)

Spring peepers are commonly found in permanent and semi-permanent wetlands surrounded by woodlands, and wetlands containing trees and bushes in and near the water (Conant and Collins 1998). In most of the Northeast, it is the most ubiquitous and readily detected anuran.

Kent (1980) reported spring peepers at MORR, indicating that they were common at Cattail Marsh (Kent, pers. comm. to R. Cook and L Morales, 2000). Oddly, there are no other records of this species at MORR. At Scherman-Hoffman Sanctuary, it is considered uncommon, due to a lack of vernal pond breeding habitat (NJ Audubon 2003). In 2000, no spring peepers were recorded at MORR, though they were heard at Scherman-Hoffman (Anderson, pers. comm.). Moreover, they are and continue to be abundant at nearby Great Swamp NWR (J. Arnold, pers. comm. 20 Oct 2000). MORR wetlands are mostly riparian, with a limited amount of lentic habitat. Limited breeding habitats, in conjunction with changes at Cattail Swamp (succession) and Cat Swamp Pond (fish introductions) appear to have brought about a localized decline in spring peepers at MORR.

Southern Leopard Frog (*Rana utricularia*)

The northern leopard frog (*Rana pipiens*) is found throughout the Northeastern and northern Midwestern regions of the United States and into Canada (Conant and Collins 1998). It is not found in New Jersey. The southern leopard frog (*Rana utricularia*) is found throughout the mid-western, mid-Atlantic, and Southeastern United States, including the entire state of New Jersey (Conant and Collins 1998; Schwartz and Golden 2002). Several park records report northern

leopard frog (*R. pipiens*), specifically from Indian Grave Brook and Cat Swamp Pond (Kent 1980; Mele 1981; Mele and Mele 1983). Similar in appearance to northern leopard frog, southern leopard frog is distinguished from northern by having a central light spot in the center of the tympanum, a rounder head and less spots on the sides of the body (Schwartz and Golden 2002). While there are no descriptions of the specimens found, it is likely that what was reported as northern leopard frog, (*R. pipiens*) was actually southern leopard frog, (*R. utricularia*). It is also possible that some specimens reported as leopard frog were actually pickerel frog. But, Kent (1980) reported both species, and we consider his report of leopard frog credible.

Southern leopard frogs utilize shallow, freshwater wetlands, are occasionally found in brackish marshes, and venture away from wetlands outside the breeding season (Conant and Collins 1998; Schwartz and Golden 2002). They range through the entire state of New Jersey. Leopard frogs are very common at Great Swamp NWR, where the extensive landscape of swamps, ponds, and flooded meadows provides ideal habitat for them (USFWS, undated).

No leopard frogs were recorded at MORR in 2000. While data on historic abundance are lacking, considering the lack of habitat for this species at MORR, it is likely it was never common. It is not include on the list of species recorded at Scherman-Hoffman Sanctuary (NJ Audubon 2003). Because this species makes extensive use of non-wetland habitats outside of the breeding season, the few old records may well represent such individuals. The lack of any records in 2000 suggests either no change in this species status at MORR or a decline, likely due to a decline beyond the boundaries of MORR reducing the numbers of individuals roaming the landscape.

Eastern Cricket Frog (*Acris crepitans crepitans*)

The eastern cricket frog ranges from southeastern New York to the Florida panhandle and east Texas and is found throughout New Jersey except for the core Pinelands. They are found in shallow permanent ponds or streams with substantial amount of vegetative cover and sunlight exposure (Conant and Collins 1998; Schwartz and Golden 2002) and is common in the Great Swamp (USFWS, undated). The only historic account of this species at Morristown is that of Kent (1980) near the Lower Primrose Seep. No eastern cricket frogs were found in 2000. Given the limited amount of suitable habitat and the fact that no observations have been reported in 25 years, we consider this species to no longer be present in the park. It is doubtful it was ever common.

Turtles

Eastern Box Turtle (*Terrapene carolina carolina*)

A small terrestrial turtle with a hinged plastron, the eastern box turtle is found in open forests, fields, and marshy meadows (Ernst et al. 1994) and is widespread in New Jersey (Schwartz and Golden 2002). This is a long-lived species known to live more than a century (Oliver 1955; Graham and Hutchison 1969).

A total of 15 eastern box turtles (RA=0.62%) were found at six different upland sites in woodlands, fields, and along roads (FO=13.3%) (Table 2 and 3, Appendix 8 and 9). This was the most common turtle found during the study. Most of the turtles (10) were found during time-constrained surveys in fields, seven of these turtles were collected in Jarvis Field, in the southeastern section of the New Jersey Brigade Unit. No new turtles were recaptured later in the season. Several of the captured turtles had four shallow slash marks on both left and right pectoral scutes of the plastron. These markings are likely from a previous capture, though the park has no records of box turtle marking. Mele and Mele (1983) recorded one box turtle near Indian Grave Brook and park records (NPS Natural History Observations 1983-1999; Morristown NPFauna 1993) suggest box turtles are common. Our results indicate this to still be true.

Box turtles are declining throughout much of their range due to the cumulative impacts of urbanization and habitat fragmentation (Dodd 2001). Considering that MORR apparently continues to support a significant population, park management should consider long term monitoring of this species, and be vigilant regarding road kills, both real and potential. Box turtles spend much of their time at the edge between fields and woodlands (Reagan 1974), and use fields for nesting in June-July, field maintenance activities (Appendix 2) should be evaluated to ensure that impacts to box turtles are minimized.

Snapping Turtle (*Chelydra serpentina*)

The snapping turtle is widespread in New Jersey. It prefers permanent bodies of fresh water but also occurs in brackish water (Schwartz and Golden 2002). These primarily aquatic turtles are common in the United States, and are frequently seen crossing roads and traveling over land in the spring and early summer in search of nesting areas. Females dig nests and deposit eggs in loose sand or soil, and the hatchlings emerge in the late summer or early fall (Ernst et al. 1994).

Mele (1981) reported this species from Cat Swamp Pond and several other reports indicate it is a common resident in the park (Mele and Mele 1983; NPS Natural History Observations 1983-1999; Rosato 1998; Morristown NPFauna 1993). Trapping in Cat Swamp Pond and the Passaic River and time-constrained searches in wetlands failed to capture any snapping turtles. Only two snapping turtles were found, these were incidental encounters at Cat Swamp Pond and along Long Hills Road located in Great Swamp National Wildlife Refuge 6.4km (4 miles) away (Tables 2 and 3, Appendix 9). Limited by the amount of permanent pond habitat present, the snapping turtle at MORR has probably always been a commonly observed, but not necessarily numerous species, primarily confined to Cat Swamp Pond and the Passaic River (NJ Audubon 2003). It status appears unchanged.

Painted Turtle (*Chrysemys picta*)

This aquatic species is common in the United States, and is recognized as four subspecies across its range. The two subspecies that occur in New Jersey are the eastern painted turtle (*Chrysemys picta picta*), and the midland painted turtle (*Chrysemys picta marginata*). The eastern painted turtle has an unmarked yellow plastron and the seams on the carapace are aligned, whereas the midland painted turtle has a variable dark marking on the plastron and alternating seams on the

carapace (Ernst et al. 1994). The painted turtle is widespread and common throughout New Jersey and is found in permanent, standing bodies of water (Schwartz and Golden 2002).

As with the snapping turtle, only two painted turtles were identified during this survey. These were found during trapping in the Passaic River and during a wetland time-constrained search in Old Channel Pond (Tables 10, Appendix 8). NPS Natural History Observations (1991, 1994) and Morristown NPFauna (1991) recorded this species from Cat Swamp Pond. However we did not record any there. Limited by the amount of permanent pond habitat present, the painted turtle at MORR has probably always been an uncommon species, primarily confined to Cat Swamp Pond and the Passaic River (NJ Audubon 2003). It status appears unchanged.

Wood Turtle (*Glyptemys insculpta*)

The wood turtle occurs in Southeastern Canada, northeastern and northern regions of Midwestern United States (Conant and Collins 1998). It is a stream dependant species, spending the majority of the fall and winter months hibernating along deep pools, under overhanging root masses or logs. During the warmer months they bask and are more active terrestrially to nest and feed (Ernst et al. 1994).

Two wood turtles, one male and one female, were captured and marked in or near the Passaic River on both MORR and the Scherman-Hoffman Sanctuary. The female was observed twice by Mike Anderson, a naturalist with New Jersey Audubon Society. In 1999, Mike Anderson also found one carapace and captured and marked two individuals in the vicinity of the Passaic River. A total of six wood turtles were marked between 1999 and 2003 at Scherman-Hoffman Sanctuary, where it is considered uncommon (NJ Audubon 2003). Wood turtles have been recorded at MORR in 1983 (NPS Natural History Observations 1983-1999) and in 1998 at a small stream near Cat Swamp Pond (pers. comm. Scott Ruhren, Rutgers University). Searches at this site in 2000 failed to find any. Collectively, these records suggest that wood turtles have been and continue to be uncommon in and around MORR and adjacent lands.

The wood turtle, listed as *Threatened* by the New Jersey Department of Environmental Protection, is the only "listed" species recorded during this survey. It is a riparian species, found in wetlands and uplands near streams. Inhabiting clean streams, the wood turtle can also be found away from water in the summer months. Its decline in NJ is likely due to habitat loss and stream degradation (Schwartz and Golden 2002). This long-lived species can persist in disturbed and fragmented habitats. However over time, without reproduction, these "living dead" individuals will die off, causing local extinctions. While MORR is too small by itself to support a viable population of wood turtle, the Passaic River and associated wetland and upland areas are important habitats for the wood turtle at MORR, and contribute to the support of the regional population. Further investigation of the size, structure, reproductive success, movements, and habitat utilization of wood turtles in and around the park is recommended to better understand its status and long-term prospects.

Stinkpot (*Sternothorus odoratus*)

The stinkpot is a widespread species in the eastern U.S whose northward extension along the coast is limited primarily to southern New England. It occurs in a broad range of waterways with slow currents and soft bottom, including rivers, streams, lakes, and ponds (Ernst et al. 1994). Distinguishing characteristics include two prominent light stripes on the side of the head, a small plastron with 11 scutes, and a single plastral hinge (Ernst et al. 1994). This species is common and widespread in New Jersey (Schwartz and Golden 2002), though its highly aquatic habits, small size, and disinclination to bask often make it appear to be less common than it actually is.

One stinkpot was captured and marked from the Passaic River (Appendix 8). It was recaptured four times. This uncommon species (RA=0.04%) was previously undocumented in the park. The stinkpot's distribution at MORR is likely limited to the Passaic River. It appears to be uncommon, and has probably always been so given the lack of previous records and limited habitat.

Snakes

Eastern Gartersnake (*Thamnophis sirtalis sirtalis*)

The eastern gartersnake is common in the United States and is recognized as many different subspecies ranging across the country. It is found in a variety of habitats including meadows, marshes, woodlands, and cultivated and developed areas (Behler and King 1979), and is widespread and common in New Jersey (Schwartz and Golden 2002).

The eastern gartersnake was among the most common and widespread species in the park (RA=3.68%, FO=35.6%) with 89 records reported from 16 sites in stream, wetland, and upland habitats and on roads (Tables 2 and 3, Appendix 8 and 9). The majority of these captures were in fields (51/89=57.3%). Mele and Mele (1983) reported one individual from East Primrose Brook, and this species, reported as common (Morristown NPFauna 1993) has been recorded from Wick Orchard and Wick Garden (NPS Natural History Observations 1983-1999). Our findings indicate this species to still be common and widespread in the park.

Northern Watersnake (*Nerodia sipedon*)

This aquatic snake inhabits swamps, bogs, ponds, and streams throughout the Northeastern and northern Midwestern United States (Conant and Collins 1998). In New Jersey, it is found throughout the entire state (Schwartz and Golden 2002).

The northern watersnake was common and moderately widespread in the park with 54 records from seven stream and wetland sites (RA=2.23%, FO=15.6%) (Tables 2 and 3, Appendix 8 and 9). The majority of these snakes were recorded from Cat Swamp Pond (39/54=72.2%). Because snakes were not uniquely marked, it is likely that these do not all represent unique individuals. Mele and Mele (1983) and NPS History Observations (1983-1999) record this species at MORR, where it has been considered common (Morristown NPFauna 1993). It is also common at

Scherman-Hoffman Sanctuary (NJ Audubon 2003). Our findings indicate it remains a common and widespread species in the park, preferring permanent bodies of water.

Northern Ring-necked Snake (*Diadophis punctatus edwardsii*)

The northern ring-necked snake is common throughout the Northeastern United States (Degraaf and Rudis 1983) and found in a wide diversity of habitats (Klemens 1993). A small, inconspicuous species, the northern ring-necked snake is typically found in moist woodlands with abundant cover and is primarily nocturnal (Hunter et al. 1999; Conant and Collins 1998). It is widespread in New Jersey (Schwartz and Golden 2002).

The northern ring-necked snake was less common than eastern gartersnake and northern watersnake (RA=0.54%) and was not very widespread in the park (FO=8.9%). A total of 13 records were reported from four sites during coverboard surveys and as incidental encounters in fields and a woodpile (Tables 2 and 3, Appendix 8 and 9). Of these, 11 were from fields (84.6%). There are a few historic records from Wick Orchard and Jockey Hollow maintenance area (NPS Natural History Observations 1983-1999; Morristown NPFauna 1993), suggesting it is uncommon, although northern ring-necked snakes are often difficult to detect. Results from this inventory indicate this species is relatively uncommon.

Eastern Milksnake (*Lampropeltis triangulum triangulum*)

The eastern milksnake ranges throughout most of the eastern United States and into southern Canada (Degraaf and Rudis 1983). It is widespread and common in New Jersey (Schwartz and Golden 2002). This is a secretive species most active at night and found in habitats ranging from woods, meadows, bogs, streams, and farmland. It is frequently associated with old farm fields, dilapidated structures, and trash piles, and thrives in human altered habitats (Klemens 1993). Identifying characteristics include a "Y" shaped, cream-colored patch on the nape, and a black and white checkerboard pattern on the belly (Hunter et al. 1999; Conant and Collins 1998).

The eastern milksnake was among the least common and least widespread species encountered in 2000 (RA=0.17%, FO=2.2%). There were a total of four records, all during coverboard surveys at Mt. Kemble Field (Tables 2 and 3, Appendix 8). It has been previously recorded a few times at MORR (NPS Natural History Observations 1983-1999) and is considered uncommon at the adjacent Scherman-Hoffman Sanctuary (NJ Audubon 2003). Our findings indicate it remains an uncommon species.

Northern Black Racer (*Coluber constrictor constrictor*)

This snake is common in fields and open woodlands from southern Maine to northeastern Alabama, and is found throughout the entire state of New Jersey (Conant and Collins 1998; Schwartz and Golden 2002). There are no historic records of black racer from MORR. At Scherman-Hoffman Sanctuary it was considered rare and now is considered extirpated (NJ Audubon 2003). None were observed at MORR in 2000. Because this is a large, active and conspicuous species, the lack of records, past or present, suggests it was, and continues to be,

rare or non-existent at MORR. MORR contains plenty of suitable field and open woodland habitat, further investigation might yet document northern black racer in the park.

Northern Brownsnake (*Storeria dekayi*)

This inconspicuous species inhabits moist upland and lowland habitats, and can be common in unpolluted urban and suburban areas (Conant and Collins 1998). In New Jersey, it is found throughout the entire state (Schwartz and Golden 2002). There are no historic records of northern brownsnake from MORR. At Scherman-Hoffman Sanctuary it is considered rare, and has not been seen in many years (NJ Audubon 2003). None were observed at MORR in 2000. While it is possible that northern brownsnakes may still be found at MORR, the record, past and present, suggests it was rare at best. Its absence in 2000 may thus be interpreted as either a maintenance of the *status quo,* or a decline from rare to absent.

Northern Copperhead (*Agkistrodon contortrix mokasen*)

Only one of two venomous snakes in New Jersey, the northern copperhead inhabits rocky, wooded uplands and wetlands and rocky talus slopes in the northern region of the state (Schwartz and Golden 2002).

Records of northern copperhead in Morristown include an anonymous report on 5 June 1988 on Route 24 near Delbarton School, and a questionable report of four northern copperheads basking on a wooden bridge along the Grand Loop Trail on 18 May 1999 (NPS Natural History Observation 1999). No copperheads were recorded in 2000. There are no data to substantiate the presence of this species, either historically or currently at MORR, and we do not believe it to be a member of the herpetofaunal assemblage at MORR.

Timber Rattlesnake (*Crotalus horridus*)

Along with the northern copperhead, the timber rattlesnake is the only other venomous snake in New Jersey. They are found in rocky wooded ledges in the northern region of the state and in swamps and pine-oak forests in the Pine Barrens (Conant and Collins; Schwartz and Golden 2002). Listed as *Threatened* by the New Jersey Department of Environmental Protection, this once widespread and regionally common species has declined in the state due to habitat loss, illegal collecting, roadside mortality, and unjustified killing (Schwartz and Golden 2002).

A timber rattlesnake was reported to have been basking at Flat Rock on 14 June 1989 (NPS Natural History Observations, 1983-1999). Because of behavioral, temporal, habitat, or any other supportive anecdotal information from local naturalists, we believe this observation to be a mistaken identity. We do not consider this species to occur now, or in the recent past, at MORR.

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Appendix 1. Species list of amphibians and reptiles historically described to be present in Morristown National Historical Park based on literature and park records. An 'X' denotes species presence as described by the accompanying reference. Species in bold are those believed to represent historically occurring wild populations.

	Kent 1980	Mele 1981	Mele&Mele 1983	NPS Natural History Obs. Cards 1983-1999	Rosato 1998	NJ Audubon Scherman/ Hoffman	Morristown NHP NPFauna 1993
FROGS							
American Bullfrog	**X**	**X**			**X**		**X**
American Toad	**X**			**X**			**X**
Gray Treefrog	**X**						**X**
Northern Green Frog	**X**	**X**	**X**	**X**	**X**		**X**
Northern Cricket Frog	**X**						**X**
Northern Leopard Frog	**X**	**X**	**X**				**X**
Pickerel Frog	**X**						**X**
Spring Peeper	**X**						**X**
Wood Frog	**X**			**X**			**X**
SALAMANDERS							
Red-spotted Newt	**X**		**X**			**X**	**X**
Four-toed Salamander	**X**						**X**
Jefferson Salamander	**X**			**X**			**X**
Long-tailed Salamander	**X**						**X**
Marbled Salamander	**X**						**X**
Northern Dusky Salamander	**X**		**X**			**X**	**X**
Northern Two-lined Salamander	**X**		**X**	**X**		**X**	**X**
Northern Red Salamander	**X**			**X**		**X**	
Eastern Red-backed Salamander	**X**	**X**	**X**	**X**		**X**	**X**
Northern Slimy Salamander	**X**		**X**	**X**		**X**	**X**
Spotted Salamander	**X**					**X**	**X**
Spring Salamander	**X**						**X**
TURTLES							
Eastern Box Turtle			**X**	**X**		**X**	**X**
Painted Turtle				**X**		**X**	**X**
Snapping Turtle		**X**	**X**	**X**	**X**	**X**	**X**
Wood Turtle				**X**		**X**	

Appendix 1. Species list of amphibians and reptiles historically described to be present in Morristown National Historical Park based on literature and park records. An 'X' denotes species presence as described by the accompanying reference. Species in bold are those believed to represent historically occurring wild populations.

	Kent 1980	Mele 1981	Mele&Mele 1983	NPS Natural History Obs. Cards 1983-1999	Rosato 1998	NJ Audubon Scherman/ Hoffman	Morristown NHP NPFauna 1993
SNAKES							
Eastern Gartersnake			**X**	**X**		**X**	
Eastern Ribbonsnake				X			
Eastern Milksnake				**X**		**X**	
Northern Black Racer						**X**	
Northern Brownsnake						**X**	
Northern Copperhead				X			
Northern Watersnake			**X**	**X**		**X**	**X**
Northern Ring-necked Snake				**X**		**X**	**X**
Timber Rattlesnake				X			

Appendix 2. Schedule of mowing frequency for fields in Morristown National Historical Park.

Field	Acres	Mowing Frequency	
Wick Apple Orchard	12.3	2-4 times/year; May-Sept	
Wick Field West	1.7	2 times/year max.; May-Sept	
Soldier Hut	7.4	2-4 times/year; May-Sept	
Grand Parade	1.8	2-4 times/year; May-Sept	
Estate Entrance	4 areas (8, 4.3, 0.4, 1.1)	2-4 times/year; May-Sept	
Visitor Center Leachfield	2.9	Once a year; Aug-Sept	
Wick Field North	6.4	Once a year; Aug-Sept	
Sugar Loaf Field	1.8	Once a year; Aug-Sept	
New York Brigade Leach	0.8	Once a year; Aug-Sept	
Maryland Brigade	6.7	Once a year; Aug-Sept	
Route 202	1.6	Once a year; Aug-Sept	
Administrative Annex	2.6	Once a year; Aug-Sept	
Mount Kemble	13.5	Once every 2 years; Aug-Sept	
Stark's Brigade	5.7	Once every 2 years; Aug-Sept	
Jarvis	42.9	Once every 2 years; Aug-Sept	
Acreage Mowed		Areas Mowed	
2-4 times/year	37	2-4 times/year	5
Once a year	22.8	Once a year	7
Once Every 2 Years	62.1	Once Every 2 Years	3
TOTAL ACRES	121.9 Acres	TOTAL # OF AREAS	15 Areas

Appendix 3. Habitat types assigned to herpetological survey sites in Morristown National Historical Park. Sub-habitat types are grouped into three main habitat categories.

Habitat Category	Habitat Type	Description
STREAMS	Permanent Stream	Narrow (<3m wide), flowing body of water with water flowing throughout the year.
	Intermittent Stream	Narrow (<3m wide), flowing body of water that dries up for a period of time during the year.
	Seep	Area where groundwater surfaces, creating a slow moving wet area; often-found on slopes.
	River	Large (>3m wide) flowing body of water, oftentimes navigable.
WETLANDS	Temporary Pond	Open or closed canopy body of water that holds water for part of the year, drying during late summer months, and is void of fish. Identified by water stained leaves and buttressed tree trunks (i.e., Pin Oak (*Quercus palustris*); Black Gum (*Nyssa sylvatica*)). Invertebrates present include fairy shrimp, predacious diving beetles, copepods, cladocerans, and caddisfly larvae.
	Permanent Pond	Open body of water (<2 ha), holds water the entire year, and fish are usually present. Borders of the pond are well defined.
	Marsh/Swamp	Body of water without well-defined borders, supporting abundant vegetation such as deciduous trees (i.e., Red Maple (*Acer rubrum*)), shrubs (i.e., Buttonbush (*Cephalanthus occidentalis*)), and emergent, herbaceous vegetation (i.e., Soft Rush (*Juncus effuses*); sedges (*Carex* spp.)). Water is usually shallow (<1m) and substrate mucky.
UPLANDS	Deciduous Forest	Forest dominated by deciduous trees (i.e., oak (*Quercus* spp.); maple (*Acer* spp.); birch (*Betula* spp.).
	Field (grass/forbs)	Open area dominated by grasses and sedges
	Road	Paved roads and trails, not a 'natural' habitat

Appendix 4. Code, common name, and scientific name of amphibian and reptile species historically reported from Morristown National Historical Park. Common and scientific names and spellings are from Crother (2000).

Code	Common Name	Scientific Name
ACCR	Eastern Cricket Frog	*Acris c. crepitans*
AGCO	Northern Copperhead	*Agkistrodon contortrix mokasen*
AMJE	Jefferson Salamander	*Ambystoma jeffersonianum*
AMMA	Spotted Salamander	*Ambystoma maculatum*
AMOP	Marbled Salamander	*Ambystoma opacum*
BUAM	American Toad	*Bufo americanus*
CHPI	Painted Turtle	*Chrysemys picta*
CHSE	Snapping Turtle	*Chelydra serpentina*
COCO	Northern Black Racer	*Coluber c. constrictor*
CRHO	Timber Rattlesnake	*Crotalus horridus*
DEFU	Northern Dusky Salamander	*Desmognathus fuscus*
DIPU	Northern Ring-necked Snake	*Diadophis punctuatus edwarsii*
EUBI	Northern Two-lined Salamander	*Eurycea bislineata*
EULO	Long-tailed Salamander	*Eurycea l. longicauda*
GLIN	Wood Turtle	*Glyptemys insculpta*
GYPO	Northern Spring Salamander	*Gyrinophilus p. porphyriticus*
HESC	Four-toed Salamander	*Hemidactylium scutatum*
HYVE	Gray Treefrog	*Hyla versicolor*
LATR	Eastern Milksnake	*Lampropeltis t. triangulum*
NESI	Northern Watersnake	*Nerodia sipedon*
NOVI	Red-spotted Newt	*Notophthalmus v. viridescens*
PLCI	Eastern Red-backed Salamander	*Plethodon cinereus*
PLGL	Northern Slimy Salamander	*Plethodon glutinosus*
PSCR	Spring Peeper	*Pseudacris crucifer*
PSRU	Northern Red Salamander	*Pseudotriton r. ruber*
RACA	American Bullfrog	*Rana catesbeiana*
RACL	Northern Green Frog	*Rana clamitans melanota*
RAPA	Pickerel Frog	*Rana palustris*
RAPI	Northern Leopard Frog	*Rana pipiens*
RASY	Wood Frog	*Rana sylvatica*
STDE	Northern Brownsnake	*Storeria d. dekayi*
STOD	Stinkpot	*Sternothorus odoratus*
TECA	Eastern Box Turtle	*Terrapene c. carolina*
THSI	Eastern Gartersnake	*Thamnophis s. sirtalis*

Appendix 5. Habitat type, survey locations, and GPS positions for 25 standardized surveys sites in Morristown National Historical Park.

Site Name	Habitat	Survey Method	GPS Positions			
			UTMX	UTMY	UTMX	UTMY
Cat Swamp Pond	perm. pond	ACC,EMC,IE, MT,TCS,TT	540052	4513075		
Cattail Marsh	marsh	ACC,IE, MT,TCS	539208	4512974		
East Primrose Brook	perm. stream	IE, TCS				
Ephemeral Pond	temp. pond	MT				
Indian Grave Brook/Marsh	marsh	ACC,IE,MT,TCS	537128	4509881	537094	4509924
			538530	4511225	538537	4511194
		CB	538557	4511051	538538	4511027
Jarvis Field	field	IE,TCS	538530	4511225		
Jersey Brook	int. stream	IE,TCS	538492	4511818	538561	4511814
Lower Primrose Brook	perm. stream	IE,TCS	593665	4512414	539675	4512500
Lower Primrose Brook Seep	seep	ACC,MT, TCS	539722	4512539	539703	4512491
Lower West Primrose Brook	perm. stream	TCS	539385	4512875	539285	4512924
		CB	539129	4512564	539108	4512584
MD Brigade Leach Field	field	TCS	539129	4512564		
			540428	4512703	540441	4512681
		CB	540496	4512865	540488	4512840
Mt. Kimble Field	field	IE,TCS	540428	4512703		
		CB	539751	4513303	539736	4513284
NJ Brigade Leach Field	field	IE,TCS	539751	4513303		
Old Channel Pond	temp. pond	ACC,IE,MT,TCS	537777	4510873		
Passaic River	river	IE,TCS,TT	537828	4510672	537852	4511091
		CB	539046	4513875	539032	4513914
Sugar Loaf Field	field	TCS	539046	4513875		
Trail Center Seep	seep	ACC,IE,MT,TCS	539325	4512926	539367	4512876
Upper West Primrose Brook	perm. stream	TCS	539176	4513024	539282	4512923
Wick Farm		CB	538471	4512753	538473	4512779
North Field	field	IE,TCS	538471	4512753		
		CB	537296	4510690	537315	4510687
Woodland#1	decid. forest	TCS	537296	4510690		
		CB	538480	4511243	538454	4511247
Woodland #2	decid. forest	TCS	538480	4511243		
		CB	538686	4512612	538676	4512639
Woodland#3	decid. forest	TCS	538686	4512612		
		CB	539820	4513789	539820	4513824
Woodland#4	decid. forest	TCS	539820	4513789		
			540089	4512184	540068	4512180
		CB	538947	4512054	538975	4512070
Woodland #5	decid. forest	TCS	540089	4512184		
			539693	4513294	539681	4513276
		CB	540448	4512896	540439	4512922
Woodland #6	decid. forest	IE,TCS	539693	4513294		

Appendix 6. Habitat type and GPS positions for 18 incidental encounter locations in Morristown National Historical Park and 2 locations in Great Swamp National Wildlife Refuge. When available, the Global Positioning System (GPS) position is presented as Universal Transverse Mercator (UTM) grid coordinates X=x-axis or East, and Y=y-axis or North.

Site Name	Habitat	GPS Positions			
		UTMX	UTMY	UTMX	UTMY
Aqueduct Trail	trail/road				
Cemetery Road	road				
Cross Estate Field	field				
Cross Estate Gardens	field				
Ephemeral Seep Area	seep				
Grand Loop Trail	trail/road				
Grand Parade Rd.	road				
Long Hills Rd. (Great Swamp NWR)	road				
Mt. Kemble Field Area	field				
Path	trail/road	538786	4513579		
Patriots Path	trail/road				
Primrose Brook	stream				
Route 202	road				
Sugar Loaf Rd./Lewis Morris Park	field				
Tour Loop Rd.	road				
Water Tower	field				
West Primrose Brook	stream				
Whitebridge Rd. (Great Swamp NWR)	road				
Wick House Woodpile	field				
Wick Orchard	field				

Appendix 7. Time constrained search at Morristown National Historic Park in 2000: First and last sampling date, number of searches, and total search effort (person hours), by habitat type and site.

Habitat Type	Site	Search Dates	Number of Searches	Search Effort (person hours)
Stream	East Primrose Brook	3/30-9/25	6	12.7
	Jersey Brook	4/1-9/18	6	5.9
	Lower Primrose Brook	3/28-9/21	6	11.7
	Lower West Primrose	3/28-9/21	6	12.0
	Passaic River	3/30-9/21	14	27.7
	Upper West Primrose	3/28-9/22	6	12.0
Total Search Effort in Steams				**81.9**
Woodland	Woodland #1	3/31-9/19	6	10.9
	Woodland #2	3/29-9/19	6	15.9
	Woodland #3	3/29-9/19	6	11.2
	Woodland #4	3/30-9/20	6	12.3
	Woodland #5	4/1-9/14	7	13.7
	Woodland #6	3/30-9/25	5	10.2
Total Search Effort in Woodlands				**74.2**
Field	Jarvis Field	4/24-9/25	5	11.8
	Maryland Brigade Field	4/14-9/20	5	5.0
	Mt. Kemble Field	4/24-9/22	5	10.9
	NY Brigade Leach Field	4/14-9/19	5	4.1
	Sugar Loaf Field	4/20-9/19	5	5.6
	Wick Farm North	4/20-9/20	5	6.1
Total Search Effort in Fields				**43.5**
Wetland	Cat Swamp Pond	3/28-9/19	7	7.1
	Cattail Marsh	3/28-9/22	6	6.1
	Indian Grave Brook Marsh	3/30-3/31	2	1.9
	Lower Primrose Brook	3/30	1	1.0
	Old Channel Pond	3/31-9/20	6	5.1
	Trail Center Seep	3/28-9/19	6	6.1
Total Search Effort in Wetlands				**27.3**

Appendix 8. Species recorded at each of 25 standardized surveys sites in Morristown National Historical Park. Frequency of Occurrence (FO) is number of sites a species was recorded from, divided by total number of sites (25). Species codes are defined in Appendix 4.

Site Name	Species																						# of Spp.
	AMMA	BUAM	CHPI	CHSE	CLIN	DEFU	DIPU	EUBI	HYVE	LATR	NESI	NOVI	PLCI	PLGL	PSRU	RACA	RACL	RAPA	RASY	STOD	TECA	THSI	
Cat Swamp Pond	X			X		X					X	X	X		X	X	X	X				X	11
Cattail Marsh		X				X		X			X		X		X		X	X				X	9
East Primrose Brook						X		X					X				X	X					5
Ephemeral Pond																							0
Indian Grave Brook/Marsh															X		X	X					3
Jarvis Field																					X	X	2
Jersey Brook						X		X					X				X					X	5
Lower Primrose Brook		X				X		X							X		X	X					6
Lower Primrose Brook Seep											X				X		X						3
Lower West Primrose Brook						X		X							X		X						4
MD Brigade Leach Field																						X	1
Mt. Kimble Field		X					X			X			X						X		X	X	7
NJ Brigade Leach Field																		X					1
Old Channel Pond			X												X	X	X	X					5

Appendix 8. Species recorded at each of 25 standardized surveys sites in Morristown National Historical Park. Frequency of Occurrence (FO) is number of sites a species was recorded from, divided by total number of sites (25). Species codes are defined in Appendix 4.

Site Name	Species																						# of Spp.
	AMMA	BUAM	CHPI	CHSE	CLIN	DEFU	DIPU	EUBI	HYVE	LATR	NESI	NOVI	PLCI	PLGL	PSRU	RACA	RACL	RAPA	RASY	STOD	TECA	THSI	
Passaic River			X		X	X		X			X				X	X	X	X	X	X			11
Sugar Loaf Field																						X	1
Trail Center Seep						X					X				X		X	X					5
Upper West Primrose Brook						X		X						X	X		X	X					6
Wick Farm North Field							X														X	X	3
Woodland#1		X											X										2
Woodland#2		X						X					X	X	X		X				X		7
Woodland#3		X											X					X					3
Woodland#4		X											X	X				X				X	5
Woodland#5		X											X										2
Woodland#6						X		X					X	X	X			X					6
Total	**1**	**8**	**2**	**1**	**1**	**10**	**2**	**9**	**0**	**1**	**5**	**1**	**11**	**4**	**12**	**3**	**13**	**13**	**2**	**1**	**4**	**9**	
FO	**0.04**	**0.3**	**0.08**	**0.04**	**0.04**	**0.4**	**0.08**	**0.4**	**0.0**	**0.04**	**0.2**	**0.04**	**0.4**	**0.2**	**0.5**	**0.1**	**0.5**	**0.5**	**0.08**	**0.04**	**0.2**	**0.4**	

Appendix 9. Species recorded at 18 incidental encounter locations in Morristown National Historical Park and 2 locations in Great Swamp National Wildlife Refuge. Frequency of Occurrence (FO) is the number of locations a species was identified from, divided by the total number of locations (20). Species codes are defined in Appendix 4.

Site Name	Species																						# of Spp.
	AMMA	BUAM	CHPI	CHSE	CLIN	DEFU	DIPU	EUBI	HYVE	LATR	NESI	NOVI	PLCI	PLGL	PSRU	RACA	RACL	RAPA	RASY	STOD	TECA	THSI	
Aqueduct Trail		X																					1
Cemetery Road																		X				X	2
Cross Estate Field		X																					1
Cross Estate Gardens																						X	1
Ephemeral Seep Area		X				X							X										3
Grand Loop Trail		X																				X	2
Grand Parade Rd.																					X	X	2
Long Hills Rd. (Great Swamp NWR)				X					X							X	X						4
Mt. Kemble Field Area		X											X						X			X	4
Path		X																			X		2
Patriots Path																	X						1
Primrose Brook		X				X		X			X		X		X		X	X					8
Route 202									X														1
Sugar Loaf Rd./Lewis Morris Park		X																					1
Tour Loop Rd.																						X	1
Water Tower							X																1
West Primrose Brook						X		X			X												3
Whitebridge Rd. (Great Swamp NWR)									X														1
Wick House Woodpile							X																1
Wick Orchard																						X	1
Total	**0**	**8**	**0**	**1**	**0**	**3**	**2**	**2**	**3**	**0**	**2**	**0**	**3**	**0**	**1**	**1**	**3**	**2**	**1**	**0**	**2**	**7**	
FO	**0.0**	**0.4**	**0.0**	**0.05**	**0.0**	**0.2**	**0.1**	**0.1**	**0.2**	**0.0**	**0.1**	**0.0**	**0.2**	**0.0**	**0.05**	**0.05**	**0.2**	**0.1**	**0.05**	**0.0**	**0.1**	**0.4**	

As the nation's primary conservation agency, the Department of the Interior has responsibility for most of our nationally owned public land and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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National Park Service
U.S. Department of the Interior

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